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Comparative Analysis of Environmental Kuznets Curve in Central and Eastern Europe and South and East Asia

Yu-chin Pang
Lynn University

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COMPARATIVE ANALYSIS OF ENVIRONMENTAL KUZNETS CURVE
IN CENTRAL AND EASTERN EUROPE AND
SOUTH AND EAST ASIA

Dissertation
Presented in Partial Fulfillment of the Requirements for the Degree of
Doctor of Philosophy
Lynn University

By
Yu-chin Pang

2007
COMPARATIVE ANALYSIS OF ENVIRONMENTAL KUZNETS CURVE
IN CENTRAL AND EASTERN EUROPE AND
SOUTH AND EAST ASIA

Pang, Yu-chin, Ph.D.
Lynn University, 2007

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Heartfelt thanks to all the wonderful people who assisted this dissertation. To Dr. Farideh Farazmand, the outstanding dissertation committee Chair, for she was very helpful in seeing the gaps and integrating academic theory to the purposes of this dissertation. To Dr. John M. Cipolla, for providing me directions, challenging my assumptions, and spending an enormous amount of time reviewing this dissertation. To Dr. Joan Scialli, for guiding my research design, commenting on my methodology, and encouraging me throughout the entire period of the research program. Their input did much to enhance the quality of this research. Finally, this dissertation is dedicated to my families and the GOD in heaven. For my dearest parents, Chiu-shi Pang and Shou-mai Pang-Fan, my husband, Lung-cheng, and my son, Timothy, this study would not be complete without their full support. For the GOD in heaven because “And we know that all things work together for good to them that love GOD, to them who are the called according to his purpose (Romans, 8:28).”
Environmental deterioration has frequently been viewed as a problem that inevitably accompanies economic development and industrialization. However, different economic backgrounds might experience different kinds and levels of environmental deterioration. This study investigated environmental deterioration in two groups of countries with comparable income levels but different economic backgrounds—transitional Central and Eastern Europe (CEE) and non-transitional South and East Asian (SEA) countries.

This research utilized the environmental Kuznets curve (EKC) hypothesis to explain the relationships among macroeconomic indicators, country categories, and atmospheric concentrations in the CEE and SEA regions. Three research questions and six hypotheses and related sub-hypotheses were answered and tested by way of secondary data from 1990 to 2006, or the most recent data available. All of the data were sourced from the World Development Indicators, published by The World Bank Group; the exception was sulphur dioxin emissions, which came from Stern (2005). Multiple regressions and independent t-test were applied to analyze the data.

The findings indicated that differing economic backgrounds undermined environmental quality in CEE and SEA. Transitional economies, CEE, showed an increasing pressure on CO₂ emissions but a decreasing pressure on SO₂ emissions.

Regarding the inverted-U EKC hypothesis, this research showed different results according to different regions. The inverted-U curvilinear EKC hypothesis was supported in CEE region. However, the regressions analysis showed different results in the SEA region. The inverted-U curvilinear relationship between GDP per capita and per
capita CO₂ emission in SEA was supported, but the inverted-U curvilinear relationship between GDP per capita and per capita SO₂ emission was partially supported. Nevertheless, the curvilinear relationships between percentage changes in GDP per capita and percentage changes in emissions, both CO₂ and SO₂, in SEA region were supported.

Other findings in this study suggested that the effects of macroeconomic indicators on per capita emissions and the effects of percentage changes in macroeconomic on percentage changes in per capita emissions, depending on research models, can differ greatly among CEE and SEA regions. This study also suggested areas, involving in more environmental deterioration indicators, explanatory variables, and country characteristics, for future research on the environmental deterioration issue.
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CHAPTER I
INTRODUCTION TO THE STUDY

It has been almost two decades since the collapse of command economies in Central and Eastern Europe (CEE), after which these countries struggled through a comprehensive transformation of their economic, political, and institutional systems in order to be more consistent with their Western counterparts (Archibald, Banu, & Gochniarz, 2004; Kornai, 2006). This transformation, however, to a market economic system causes a double-edged effect from the macro and micro perspectives. From the macro perspective, the transformation took place peacefully and was surprisingly rapid in the radical direction of economic reorientation and the political reorganization of Western capitalism (Kornai, 2006). However, from the micro perspective, the transformation exacerbated daily life of people residing in this area, because high inflation and unemployment rates caused a decrease in social welfare benefits, especially during the early years of transformation (Inotai, 1995; Kornai, 2006; Shrivastave, 1995).

There is a growing volume of literature from various perspectives, both in macro and micro areas, criticizing the effects of the transformation from central planned economy to market capitalism in CEE countries (Archibald et al., 2004; Fischer, 2001; Gros & Suhrcke, 2000; Kornail, 2006; Radej & Zakotnik, 2003; Sikor, 2002; Smith & Hills, 2003). The intention of this study was to compare the impact of economic transition of these CEE countries on their environmental pollution and compare the later with environmental deterioration of non-transition economies of South and East Asian countries. The focus of environmental pollution primarily was on the air emissions.
The structure of this assessment is as follows: Chapter I began with an introduction of the background, problems, purposes, and research plans of this investigation. Chapter II describes the literature and explores gaps among existing studies. Chapter III then presents the methodology, indicators, and data sources utilized in this investigation. Chapter IV provides results according to the methodology and data section. Finally, Chapter V addresses the conclusions, comments, and recommendations in the matter of comparing the environmental deterioration and economic growth in CEE and South and East Asian countries since 1990.

Introduction and Background to the Problem

The eight CEE countries, including the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovak Republic, and Slovenia, were the most advanced countries in the former centrally-planned economies (Gros & Suhrcke, 2000; Kornai, 2006). Industrial development was a prioritized ahead of environmental protection during the forty years of planned economy for the CEE countries; this resulted in overindustrialization, misindustrialization, and economic inefficiency coupled with environmental deterioration in this area (Inotai, 1995; Juhasz & Ragno, 1993; Turnock, 2001; Zamparutti & Gillespie, 2000). Consequently, the CEE was extensively polluted, from atmospheric emissions to land degeneration, when compared with their Western European neighbors (Juhasz & Rango, 1993; Kahn, 2002). For example, the amount of sulphur oxide emissions in Kraków, Poland, was greater than the aggregated amount of sulphur oxide emitted into the whole of Western Europe (Potoschnig, Laslett, Bates, & Adamson, 1996). In fact, CEE countries were widely regarded as being among the most
polluted areas on earth (Juhasz & Rango, 1993; Kahn, 2002; Kukla-Gryz & Zylicz, 2004; Rojsek, 2001; Wang et al., 2006).

**Purpose of Study**

Most of the existing studies compared CEE countries with advanced and high-income countries of the OECD (Organization for Economic Co-operation and Development), and assumed OECD countries as a model in explaining the relationship between economic growth and the environmental development process (Archibald, Banu, & Bochniarz, 2004; Kukla-Gryz & Zylicz, 2004; Inotai, 1995). The OECD model did not seem to be the case for CEE because CEE is different from OECD countries in both their economic system and income level (Gros & Suhrcke, 2000). However, studies have shown that many economic indicators and income level were known to be related to the environmental standards (Gros & Suhrcke, 2000). In other words, one should compare the relationship of environmental deterioration and economic growth among countries that are of similar income but which differ in environmental regulation, economic systems, and global cooperation for environmental improvement.

South and East Asian (SEA) countries, including Indonesia, Korean Republic, Malaysia, the Philippines, Singapore, and Thailand, are classified as having a similar income level to CEE countries (The World Bank, 2007). SEA; therefore, these countries were chosen in this study as a group that was comparable to CEE countries for the purposes of analyzing the relationship between environmental deterioration and economic growth. Also, considering the fact that SEA economies are market economies and CEE economies are transition economies, the impact of differentiable economic
backgrounds with comparable income levels on the environment was investigated (Gros & Suhrcke, 2000).

The purpose of this investigation was to compare the environmental deterioration and economic growth of transitional (CEE) and non-transitional (SEA) economies. Central and Eastern European and South and East Asian countries have comparable income per capita but different backgrounds in the timeframe of 1990-2006. The objectives of this study included:

1. Describe the macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and environmental pollution measures of per capita emissions (CO$_2$ and SO$_2$) of all CEE and SEA countries.

2. Determine whether there is a significant curvilinear explanatory relationship between macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and per capita emissions (CO$_2$ and SO$_2$) in the CEE and SEA countries.

3. Determine whether there is significantly less environmental deterioration (CO$_2$ and SO$_2$) in the transitional economies of the CEE than in the non-transitional economies of the SEA.

The first objective was to inquire as to the long term tendencies of macroeconomic and emissions indicators in CEE and SEA countries. The second objective required examination of the environmental Kuznets curve hypothesis in relation to CEE and SEA. Objective 3 explored whether transformation was a significant variable in explaining environmental deterioration in CEE and SEA countries.
Definitions of Terminology

The Environmental Kuznets Curve Hypothesis

The most well-known approach that addresses the relationship between economic growth and environment quality is the Environmental Kuznets Curve hypothesis (Dasgupta, Laplante, Wang, & Wheeler, 2002; Yandle, Bhattarai, & Vijayaraghavan, 2004). The Environmental Kuznets Curve (EKC) hypothesis declares a statistical curvilinear inverted-U relationship between environmental deterioration and per capita gross domestic product (GDP) (Iwami, 2004; Lekakis, 2000; Dasgupta et al., 2002; Yandle et al., 2004). According to the EKC hypothesis, the environmental quality initially degenerates as per capita GDP increases, and then it begins improving as income approaches a certain level (Iwami, 2001; Lekakis, 2000; Dasgupta, 2002). However, emerging reviews and arguments related to the EKC hypothesis have arisen as a result of the availability of a greater number of economic and socioeconomic variables in research, suggesting an enriched and varied inverted curvilinear relationship between environmental deterioration and economic growth (Gidding, Hopwood, & O’Brien, 2002; Iwami, 2001; Stern, 2004a; Turnock, 2000).

Economists have recently begun to deal with factors such as economic structure, industrialization, foreign direct investment, international trade, technological improvement, and the latecomer advantage in analyzing environmental quality (Bruvoll & Medin, 2003; Panayotou, 2000; Zaim & Taskin, 2000). Political economists turn their attention to the effects of legislation, international regulations or protocol, and fiscal spending on environmental protection (Lim 1999; Min, 2003; Pearch & Palmer, 2001). Sociologists focus on the relationships between environmental degeneration and
urbanization, literacy, mortality, and population growth. Population growth is the main force that drives environmental degeneration, according to most sociological studies (Gidding et al., 2002; Israel & Levinson, 2004; Kaivo-oja, Luukkanen, & Malaska, 2001; Panayotou, 2000; Shrivastave, 1995).

### Economic System

The economic system comprises a mechanism or social institution that allocates resources in production, distribution, and consumption of goods and services in a particular society (Papava, 2002; Porket, 1998). Based on decision-making mechanisms and ownership of resources, there could be four types of economic systems: market capitalism, command capitalism, market socialism, and command socialism (Papava, 2002; Porket, 1998; Huang, 2002; Wang et al., 2004).

**Market Capitalism**

The market capitalism system is one in which private firms and households enjoy a high degree of autonomy, acting based on self-interest with the objectives of profit and utility maximization (Blodgett, 1994; Porket, 1998; Rosser & Rosser, 2004; Huang, 2002). Countries like Britain, France, Germany, Italy, Japan, and the U.S. are some of the representatives of this economic system, but they do not represent it in its pure form, since government intervention in the economy does occur (Blodgett, 1994; Porket, 1998; Rosser & Rosser, 2004; Huang, 2002).

**Command Capitalism**

Command capitalism is characterized as private ownership of production facilities with government arranging and regulating economic activities (Porket, 1998). Command
capitalism is not common, and an example is Nazi Germany during 1933 to 1945 (Porket, 1998).

**Market Socialism**

Market socialism coordinates demand and supply of goods and services by a market price mechanism, but the factors of production are publicly owned (Porket, 1998). The former Yugoslavia was an example of economies based on the model of market socialism (Porket, 1998). Chinese economy could be a variety of market socialism as well (Porket, 1998).

**Command Socialism**

Command socialism, also called central planning, is the antithesis side of market. Government owns resources and determines and plans all production, distribution, and allocation of resources, services, and goods (Papava, 2002; Porket, 1998). Former CEE and the Soviet Union are examples of this model (Boldgett, 1994; Papava, 2002; Porket, 1998).

**Transitional Economy**

Transitional economy is a relatively new term. It is used to describe those countries that are in the process of transitioning from one economic system, usually central planning, to another system, usually market capitalism (McGee & Preobragenskaya, 2005; Papava, 2002; Smith & Hills, 2003; Warner, 2005).

**Macroeconomic Indicators**

**Economic Growth**

**Theoretical definition.** Economic growth is measured by a change in the production capacity of a country over a certain period of time (Goodwin, Nelson,
GDP and GDP per capita are two major indices in measuring economic growth (Gros & Suhrcke, 2000; Nordhaus, 2002).

Operational definition. GDP and GDP per capita are widely cited as indicators of economic growth in econometric analysis (Archibald et al., 2004; Dasgupta et al., 2002; Gros & Suhrcke, 2000; Smith & Hills, 2003; Spangenberg, 2004). GDP is the market value of all final goods and services produced in a country within a year (Schiller, 2005). In this study, GDP per capita in constant 2000 US dollars is used to measure economic growth.

GDP per Unit of Energy Use


Operational definition. GDP per unit of energy use is the GDP-per-kilogram-of-oil equivalent of energy use in constant 2000 purchasing power parity (PPP) dollar per kilogram of oil equivalency (The World Bank, 2007). Energy use refers to domestic production plus imports and stock changes, minus exports and fuels supplied to ships and aircrafts engaged in international transport (The World Bank, 2007). Purchasing Power Parity (PPP) describes a theory of determination of long term equilibrium exchange rate
between two currencies. According to the PPP theory described by Taylor and Taylor (2004),

"...a unit of currency should be able to buy the same basket of goods in one currency as the equivalent amount of foreign currency can buy in foreign country, so that there is parity in the purchasing power the unit of currency across the two economies." (p. 2)

**Secondary Industry to GDP**

*Theoretical definition.* Secondary industry to GDP is the total contributions of the industrial sector to the total GDP of a country (Iwami, 2005; Papava, 2002; Porket, 1998). The industrial sector includes mining, manufacturing, construction, and public utilities sectors which include electricity, water, and gas supplies (The World Bank, 2007).

*Operational definition.* Industry sector is measured by value added in mining, manufacturing, construction, and public utilities sectors, which include electricity, water, and gas supplies (The World Bank, 2007). Value added is the net output of a sector after adding up all output and subtracting intermediate inputs (The World Bank, 2007). Data of secondary industry to GDP are in constant 2000 US dollars for the time period in this study.

**Foreign Direct Investment**

*Theoretical definition.* Foreign direct investment is investment by foreign investors in physical assets for controlling decision-making in production, distribution, pricing, and other business activities of an enterprise (Carter & Turnock, 2005; Froot, 1994; Moosa, 2002).
Operational definition. Percentage of foreign direct investment to GDP of a country is an operational variable of foreign direct investment in this study. The data on foreign direct investment are in constant 2000 US dollars for time series purpose in this investigation.

International Trade

Theoretical definition. International trade is the share of the sum of a country’s total export of goods and services plus total import of good and services from GDP (Hockman & Djankov, 1996).

Operational definition. Percentage share of international trade to GDP, or value of exports plus imports to GDP, will measure the value of international trade in this study. International trade of a country aggregates total exports and imports of goods and services (Hockman & Djankov, 1996; The World Bank, 2007). Exports include goods and services that are produced domestically but sold abroad (Hockman & Djankov, 1996). Imports are goods and services that are produced abroad but consumed domestically (Hockman & Djankov, 1996).

Environmental Deterioration

Environmental deterioration involves a variety of pollutants and includes degeneration and acidification of soil, loss of biodiversity, extinction of flora and fauna, aggravation of atmosphere pollution, over-use of natural resources, oxidation in water supply, desertification and deforestation, ozone depletion and accumulation of greenhouse gases, and changes in climate (Lang, 2003; Min, 2003; Turner, Clark, Kates, Richards, Mathews, & Meyer, 1991; York, Rosa, & Dietz, 2003). Due to data
availability, this study only focuses on the atmosphere emissions of carbon dioxide (CO₂) and sulphur dioxide (SO₂).

**Carbon Dioxide (CO₂)**

**Theoretical definition.** The burning of coal and petroleum, the manufacture of cement, and deforestation are major causes lead to increased man-made carbon dioxide (Codur, 2004; The World Bank, 2007). Increasing the amount of CO₂ in atmosphere will enhance the greenhouse effect, which contributes to global warming (Codur, 2004). About 24 billion tons of CO₂ are released from fossil fuels per year worldwide (The World Bank, 2007). High-income countries are the major sources of man-made carbon dioxide (The World Bank, 2007). People in high-income countries consumed more than 13 tons of CO₂ per capita in 2005, as compared with 4 tons per capita world average, 3 tons per capita in middle-income countries, and 1 ton in low-income countries in 2005 (The World Bank, 2007).

**Operational definition.** CO₂ per capita, measured in metric tons, was the operational definition of carbon dioxide in this study (The World Bank, 2007).

**Sulphur dioxide (SO₂)**

**Theoretical definition.** Man-made sulphur dioxide is produced by various industrial processes, particularly the burning of poor-quality coal and petroleum. The emission of sulphur dioxide results in sulfuric acid and acid rain which can change the global climate, increase the acidity of the soil, and affect the chemical balance of lakes and streams (Barguin, 2006; Böhringer, 2003; Codur, 2004). In other words, emissions
of SO$_2$ are likely to change ecological systems by loss of biodiversity and extinction of flora and fauna (Barguin, 2006; Böhringer, 2003; Codur, 2004).

**Operational definition.** SO$_2$ per capita, measured in metric kilograms, was the operational definition of sulphur dioxide in this investigation (Stren, 2005).

**Central and Eastern European Countries**

**Theoretical Definition**

The CEE in this study included the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, the Slovak Republic, and Slovenia. These countries were not only perceived as the most advanced countries in the former communist society but also were the first transitional economies to join the European Union in 2004 (Gros & Suhrcke, 2000; Kukla-Gryz & Zylicz, 2004). The CEE countries, moreover, are classified as high-income countries, (Slovenia), or middle-income countries (the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, and the Slovak Republic) (The World Bank, 2007).

**Operational Definition**

Macroeconomic and environmental emissions indices of eight CEE countries were utilized in this study. Macroeconomic indices included GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade. Emissions indices include emission of CO$_2$ and SO$_2$.

**South and East Asian Countries**

**Theoretical Definition**

The SEA countries in this investigation include Indonesia, the Korean Republic, Malaysia, the Philippines, Singapore, and Thailand. Economic characteristics of these countries include: (1) classification as high- or middle-income countries: these countries
are either classified as high-income, (Singapore and the Korean Republic) or middle-income countries (Indonesia, Malaysia, the Philippines, and Thailand) (The World Bank, 2007); (2) similarities in economic development strategy: most SEA attract foreign direct investment priorities to stimulate economic growth (Gros & Suhrcke, 2000; Shrivastave, 1995); (3) reliance on the industrial sector: SEA countries depended on industrial expansion heavily during their development process (Gros & Suhrcke, 2000; Shrivastave, 1995); (4) similarities in economic system: all SEA countries are market economies.

**Operational Definition**

Macroeconomic and environmental indices of six SEA countries, namely Indonesia, the Korea Republic, Malaysia, the Philippines, Singapore, and Thailand, are utilized in this study. Macroeconomic indices include GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade. Environmental indices included emissions per capita of CO$_2$ and SO$_2$.

**Delimitations and Scope**

This study compared the factors that influenced environmental quality in the CEE and SEA countries. Factors included per capita GDP, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade. At the same time, this study excluded fiscal policies of governments for environmental improvement spending, urbanization, income inequality, policies of government, environmental regulations, literacy, mortality, and cultural dimensions of nations. This research covered economic and environmental data from 1990 to 2006 based on availability of data in CEE and SEA countries. The time before 1990 was excluded because the transition countries were not established until after that time.
Justification

Significance

This research was important not only because the changes of CEE countries in reorientation to market economic system is significant in contemporary world history but also because

1. The CEE countries provide an infrequent economic example of countries in process of transition from command economic system to market-oriented economies. Issues and themes from social, political, and economic development perspectives could extend the boundaries of existing theory that has been applied to predominantly capitalist societies.

2. These CEE countries have made the transition through comprehensive transformations from a command socialist economy to a market capitalist system. The relationships between economic growth and environment quality in the CEE countries are assessed to see whether the CEE countries have been following the same trajectories for the past decades as most Western capitalist countries took following an economy-environment developmental direction.

3. The topic area was selected because of the apprehension that the CEE countries were economically inefficient and suffering from environmental deterioration after forty years of a centrally planned economic system. CEE countries are experiencing a tremendous transformation from central planned to market oriented economic system, and such transformations are rare in the history of economic development. Therefore, these transitional countries
provide a unique laboratory for dealing with the relationship between economic development and environmental deterioration.

4. There has not been a comparison between environmental deterioration of transition economies and market economies in process of growth.

**Researchability**

The focus on comparing the relationship of economic growth and environmental deterioration between CEE and SEA countries was measurable variables reflected in the research questions and hypotheses. Theories, empirical studies, and data in regard to economic development and environmental deterioration were well documented.

**Feasibility**

Variables and data reflected in this study were well defined in journals, books, and publications of international organizations, international organizations, private institutions, individual projects, and etcetera.

**Summary of Chapter I**

Chapter I, the introduction of the study, consisted of three primary elements: introduced the problems, identified the primary aims and objectives, and outlined the key areas to be covered in this study. The problems associated with CEE countries in economic development and environmental deterioration included the concern that these transitional economies put industrial development ahead of environmental protection during the 40 years of development of their economic system, resulting in overindustrialization, misindustrialization, and economic inefficiency coupled with environmental deterioration. The objective of this chapter was to assess the impact of the fundamental transformation of CEE countries to market economy, focused on comparing
the environmental deterioration between transitional CEE and non-transitional SEA countries since 1990. Macroeconomic indices, per capita GDP, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade, as well as emissions indices per capita CO$_2$ and SO$_2$ in CEE and SEA countries, were key delimitations in this study. Governments’ fiscal policies for environmental improvement spending, urbanization, income inequality, policies of government, environmental regulations, and cultural dimensions of nations were excluded in this study.

The next chapter, Chapter II, the Literature Review, focused on analysis of what was known and unknown in previous investigations. The gaps in the existing literature were identified at the end of Chapter II.
CHAPTER II
REVIEW OF THE LITERATURE

Today's environmental deterioration raises numerous issues, such as desertification, deforestation, extinction of flora and fauna, ozone depletion, the accumulation of greenhouse gases, and availability of resources (Turner et al., 1991; York et al., 2003). These serious issues are addressed by sociological and economical theories, but have not yet been sufficiently examined in empirical terms, especially in comparing economic-environmental relationship in different economic backgrounds. Therefore, this chapter cited literature to support the investigation of the relationship between economic growth and environmental deterioration, with a focus on factors influencing environmental quality in different economic background countries—Central and Eastern Europe, which are transitional economies, and the South and East Asia, which are non-transitional economies.

Literature Review

IPAT Model

The Environmental Impact (I), Population (P), Affluence (A), and Technology (T) (IPAT) model addressed the relationship between environmental problems and the socioeconomic causes of environmental deterioration (Cramer, 1998; Daily & Ehrlich, 1992; Graedel & Allenby, 2002; York, Rosa, & Dietz, 2002; York et al., 2003). In this model, “I” represents environmental problems, such as air emissions; “P” portrays demographic development, which is normally reflected by population size; “A” describes affluence or per capita welfare in general, or per capita GDP, otherwise known as per capita consumption in particular; and “T” explains the technological position, primarily
the technological relationship between demographic and economic development and its impact on the environment (Daily & Ehrlich, 1992; Ehrlich & Ehrlich, 1991; Taylor, 2002; York et al., 2003).

The IPAT model specifies that environmental impacts (I) are generated as a multiplicative product of population size (P), affluence or per capita GDP (A), and technological position (T). Then the equation turns to the following algebraic relationship (Cramer, 1998; Ehrlich & Ehrlich, 1991; York et al, 2002, York et al., 2003)

\[ I = P \ast A \ast T \]

\[ = P \ast \frac{GDP}{P} \ast \frac{I}{GDP} \]

This simple mathematical formula allows for the estimation of possible effects of an impact by varying any of the course variables and assigning a priority to those variables (Cole & Neumayer, 2004; York et al., 2003). In fact, the core merits of the IPAT model are that is simple, systematic, and complete (Dietz & Rosa, 1994). It is simple because the equation covers key anthropogenic factors in a succinct equation. It is systematic because the IPAT formula assesses the mathematical relationship between the independent variables and their environmental impacts. Finally, it is complete because IPAT applies to a broad range of environmental emissions instead of a single emission (Dietz & Rosa, 1994).

The IPAT model illustrates environmental deterioration by relating anthropogenic factors of equal importance and interdependence (Daily & Ehrlich, 1992; Ehrlich & Ehrlich, 1991; York et al., 2002; York et al., 2003). According to this multiplicative equation, York et al. (2002) believed that debate on the primacy of one factor over the others was inappropriate, due not only to the trade-off relationship between impacts, but
also to the algebraic relationship equation. Technological improvement, for example, might on one hand reduce certain type of impacts, such as desertification, while increasing ozone depletion and accumulating greenhouse gases on the other. As a result, concentrating upon only one impact in a certain region within a limited time-frame can be misleading in assessing the importance of driving forces in the IPAT model (Cole & Neumayer, 2004; Fischer-Kowalski & Amann, 2001; York et al., 2002; York et al., 2003).

The IPAT model, however, has not been widely accepted by social scientists for some specific reasons. First, many socioeconomic variables, such as economic structure, regulations, and fiscal policies, have been abridged or subsumed into the T term rather than being estimated separately, weakening the ability to specify factors that could explain environmental deterioration (Cramer, 1998; Dietz Rosa, 1994; Fischer-Kowalski & Amann, 2001; Taylor, 2002; York et al., 2003). At the same time, the specific algebraic relationship between I, P, A, and T, with no error term, has reduced the potential of hypothesis testing, because the model does not provide a sufficient framework for decoupling factors of anthropogenic environmental change (Dietz & Rosa, 1994; Fischer-Kowalski & Amann, 2001; York et al., 2003). In this model, moreover, a relationship between each variable exists that is multiplicative rather than additive. Consequently, changes in any single factor will disproportionately amplify or reduce the impact of that factor because of the multiplicative relationship between each causal factor (Dietz & Rosa, 1994; Fischer-Kowalski & Amann, 2001; York et al., 2003).

York et al. (2003), utilizing ordinary least square regression to test the effects of theoretical variables on the ecological footprint, covered 142 nations and over 97% of the world population. Variables contained three perspectives, those of human ecology,
modernization, and political economy. The authors concluded that the environment changes proportionately with modernization and human ecology variables, such as the population, age structure of the population, consumption pattern, and urbanization. York et al. pointed out especially that

because of high levels of consumption in affluent nations, even a slow rate of population growth in these nations is at least as great a threat to the environment as is a rapid rate of population growth in less developed nations. (p. 295)

However, political economy variables, such as civil liberties, service sector development, and the presence of a capitalist system, had no significant effect on environmental impacts.

The results of York et al. (2003) are consistent with neo-Malthusian analyses, when energy consumption increases much faster than the population, and if most energy comes from polluting and non-renewable sources, then the pollution appears more imminent (Bartlett, 2004). Some questions, however, regarding internal and external validity could be asked. For internal validity, York et al. identified the entire environmental question in terms of one variable, footprint—i.e., the land area in hectares that is required to support the consumption of the nation-state. It is difficult to determine which environmental problems—among emissions, desertification, deforestation, extinction of flora and fauna, ozone depletion, or accumulation of greenhouse gases—are more serious than others in contributing to environmental degeneration. That is, it will be less of a help in forming policies and decision-making aimed at eliminating environmental problems. For external validity, York et al. investigated footprints of 142 countries over 97% of world population in 1996. It covered a wide range of economies, from high-income to low-
income countries. Segmentation, therefore, of these 142 countries into different groups is suggested to eliminate the heteroscedasticity in data. Moreover, a tendency towards ecological change cannot be identified, since the available data covered 1996 only in their study.

Islam, Vincent, and Panayotou (1999) and Panayotou (2000) identified analogous effect with a divergent equation that looks at three dimensions affecting the environment: scale effect, structure effect, and abatement effect. The scale effect generally covered the scale of economic activities in terms of GDP per unit of area. The structure effect reflected formation of the effect of economic activities on environmental quality by shifting the composition of economic activities toward sectors of higher or lower pollution intensity. The abatement effect was comprised of the effect of income on the demand and supply of environmental quality. This multiplicative production equation converts into the equation

\[
\begin{align*}
\text{Ambient Pollution Level} &= \text{GDP per unit of Area} \times \text{Composition of GDP} \times \text{Abatement Effect} \\
\text{Per capita impact} &= \text{Scale Effect} \times \text{Structure Effect} \times \text{Abatement Effect}
\end{align*}
\]

This algebraic formula then turns into

\[
\frac{\text{Impact}}{\text{Population}} = \frac{\text{GDP}}{\text{Population}} \times \frac{\text{Sector production}}{\text{GDP}} \times \frac{\text{Impact}}{\text{Sector production}}
\]
This equation did not deviate from the IPAT model on a fundamental level. Instead of focusing on population, as emphasized by the biological and ecological sciences, the model of Islam et al. (1999) and Panayotou (2000) turned its attention to per capita emission and the structural effects of economic activities, sector production divided by GDP, on environmental deterioration. The equation of Islam et al. and Panayotou, however, inherited both advantages and disadvantages that existed in the IPAT model.

According to Islam et al. (1999) and Panayotou (2000), if all else were constant, the scale effect on per capita impact would be a monotonic increasing function of income, since the larger the scale of economic activity per unit, the higher the level of pollution. The net structure, or composition, effect on pollution level was an inverted-U relationship (Islam et al., 1999; Panayotou, 2000). When economic structure shifts from an agriculture-intensive sector to an industry-intensive sector, income increases, with a consequential increase in pollution. As economic structure continues to change from industry-intensive to services-intensive, while income continues to increase, environmental deterioration slows down. The impact of an economy’s structural change on environmental quality, therefore, is non-monotonic, first increasing and then decreasing. Moreover, since income tends to influence willingness to pay for environment-friendly goods positively and significantly, a higher income allows an increase in the expenditure of private and public sector on pollution abatement goods (Hökby & Söderqvist, 2003; Israel & Levinson, 2004; Panayotou, 2000). As a result, an increase in the demand for pollution abating goods will induce firms to produce more environment-friendly goods, leading to environmental improvement. To summarize the
issues addressed above, the relationship between environmental deterioration and per capita income is not fixed or monotonic along a development pattern.

Even though the model of Islam et al. (1999) and Panayotou (2000) was helpful in proposing an initial stage for structuring frameworks on the relationship between social, economical, and environmental deterioration, their model attributes environmental deterioration into several simple factors without missing variables. This has depressed the possibility of hypothesis testing for future research (Dietz & Rosa, 1994; Fischer-Kowalski & Amann, 2001; York et al., 2003). This model, at the same time, analyzes the total pollutions deteriorated whole environment instead of the effects of single pollutions, such as carbon dioxide emission, and thus has delimited investigation on specific pollutants or degeneration factors. Furthermore, a multiplicative relationship between factors results in a multiplicative amplification or mitigation of environmental deterioration. Equal importance and interdependence between explanatory variables represent some other limitations when applying Islam et al. and Panayotou’s model in investigating environmental issues. Briefly, Islam et al. and Panayotou’s model is based on environmental deterioration with social perspectives and is a schematic model depicting direct and indirect relationships among concepts described by the EKC hypothesis, which continues to be examined today (Iwami, 2004).

The Environmental Kuznets Curve Hypothesis Model

In 1992, The World Bank group illustrated an inverted-U curvilinear relationship between per capita GDP and environmental deterioration in a two-dimensional figure. Since then, this inverted-U curve has become an important framework in debating human behaviors regarding economic growth and pollution (Dasgupta et al., 2002; Iwami, 2001).
In 1995, the inverted-U curve was named the Environmental Kuznets Curve (EKC) hypothesis by Gossman and Krueger (Dasgupta et al., 2002; Gossman & Krueger, 1995; Iwami, 2001; Yandle et al., 2004). Kuznets’ name was attached in the EKC hypothesis because Gossman and Krueger (1995) drew an analogy with the original inverted-U Kuznets Curve, which shows the relationship between income inequality and economic development that was postulated by Kuznets in 1955 (Ansuategi, 2003; Copeland & Taylor, 2004; Dasgupta et al., 2002; Panayotou, 2000).

The EKC hypothesis is a statistical relationship between income and environmental quality (Iwami, 2001)

...that the growth of the income per capita goes along with a decline in environmental quality up to a turning point, beyond which this relationship is reversed in the sense that the income growth coincides with the reduced environmental damage. (p. 605)

That is, the EKC hypothesis addresses the idea that environmental deterioration is a non-monotonic function of per capita GDP, first increasing up to a turning point and then decreasing (Deacon & Norman, 2004; Panayotou, 2000; Yandle et al., 2004).

Although the findings of the EKC hypothesis, a reduced form model, do not indicate any causality between economic growth and environmental variation, the EKC hypothesis caused considerable controversy. Early studies focused on whether an inverted-U curve relationship did exist in every pollutant (Cole, Rayner, & Bates, 1997; Carson, Jeon, & McCubbin, 1997; Grossman & Krueger, 1995; Selden & Song, 1995). Later studies focused on factors behind pollutants (Archibald et al., 2004; Iwami, 2003; Kukla-Gryz & Zylicz, 2004; Panayotou, 2000; Yandle et al., 2004).
Early studies in the EKC concentrated on two perspectives: first, whether a given environmental indicator exhibited an inverted-U curvilinear relationship associated with rising levels of income per capita; and second, whether calculating the turning point of given environmental indicator showed the existence of an inverted-U curve (Cole et al., 1997; Grossman & Krueger, 1995; Selden & Song, 1994, 1995). Cole et al. (1997), Grossman and Krueger (1995), Panayotou (1997), Selden and Song (1994, 1995), and Shafik and Bandopadhyay (1992) used a number of environmental indicators, such as carbon dioxide, sulphur dioxide, and carbonated fluorocarbons, to find out if EKCs existed. Their inquiries conformed to the EKC, with a turning point between $6,700 and $25,300 (in 2003 US dollars) in OECD countries. Dasgupta et al. (2002) and Stern (2004), however, argued that “Grow first, then clean up” (Dasgupta et al., 2002, p. 147) would be the only choice for environmental policy-making in developing countries if the EKC hypothesis was appropriate for most environmental issues.

Later researchers turned their focus to microeconomic and macroeconomic indicators, such as willingness to pay for environmental goods, technological improvement, technologic diffusion, foreign direct investment, trade liberalization, and the advantage of being latecomer economies, in order to have a complete understanding of the economic-environmental relationship (Fischer-Kowalski & Amann, 2001; Galeotti & Kemfert, 2004; Hökby & Söderqvist, 2003; Lindmark, 2004; Smulders, Bretschger, & Egli, 2005; Pearch & Palmer, 2001). However, the results of these studies were miscellaneous.

Cernat and Vranceanu (2003), Lian (2005), and Zarsky (1999) suggested that environmental quality will be improved by attracting foreign direct investments and
liberalizing trade, because this not only enlarges a country’s production but also enhances production efficiency by improving technologies with less polluting impact. Botcheva-Andonva, Mansfied, and Milner (2005), Mabey and McNally (1998) criticized the effects of foreign direct investment and trade liberalization on environmental issues. They believed that foreign investors will maximize pollution capacities to meet the minimum volumes of pollution allowed in the host countries. If so, pollution in the host country will stay at a certain level instead of decreasing even applied new environmental improving production process from foreign investors (Botcheva-Andonva, Mansfied, & Milner, 2005; Mabey & McNally, 1998).

Mathew (2002), Perkins and Neumayer (2005) proposed that latecomer economies can diffuse new environmental technology more easily than early environment-improving-technology adopters. Iwami (2005) conducted an inquiry in South and Eastern Asian countries, and also suggested that latecomer economies can diffuse new technology in a shorter time than earlier adopting countries; however, it cannot conclude latecomer countries would invariably benefit from adopting new technology without conditions. In furtherance of the aim of reviewing the EKC hypothesis, an additional survey on microeconomics and macroeconomics factors analysis was addressed in follow sections.

**Microeconomics Analysis**

*Elasticity analysis.* Antle and Heidebrink (1995), Hökby and Söderqvist (2003), and Israel and Levinson (2004) have investigated the EKC hypothesis from the elasticity theoretical perspective. They suggested that when income increases but still stays at a low-income stage, a growth in income will lead to environmental deterioration, because considerable resources will consumed, while environmental protection will be a low
priority. At a later stage, however, as income continues to grow to a certain level, demands for environmental protection increase, leading to an expansion in both economic development and environmental improvement. Therefore, an inverted-U shape of EKC was formed. In other words, according to these authors, elasticities of environmental quality varied with the different income levels. At a lower income stage, when environmental quality was normal goods, which means that changes in percentage of demand of environmental quality become lesser as proportional income increases. At this stage the income elasticity of environmental quality is less than 1. When income keeps increasing beyond a certain point, however, environmental quality becomes a luxury, which indicates that changes in percentage of demand of environmental quality become greater as proportional income increases. At this stage the income elasticity of environmental quality is greater than 1.

In order to obtain an inverted-U EKC, a significant point one must bear in mind is that elasticity of environment friendly goods must vary from less than 1 to greater than 1 as income increases. Empirical studies, however, did not confirm this point fully (Carson, Flores, Martin, & Wright, 1994; Hökby & Söderqvist, 2003; Kristöm, 1995; Pearce & Palmer, 2001). Hökby and Söderqvist (2003) conducted an inquiry of the elasticities of demand and willingness to pay for environmental services in Sweden. They concluded that the income elasticity of most environmental services was greater than 0 but less than 1, even when the income level was beyond the turning point of EKC. Pearce and Palmer (2001) tested the role of the income elasticity on willingness to pay for the environmental services of OECD countries, and concluded an elasticity of 1.2. Though the elasticity of environmental services in these OECD countries was greater than 1, it was far less than
expected if the downward sloping part of EKC existed (Pearce & Palmer, 2001). McConnell (1997) believed that there was no evidence to indicate that income elasticity has a statistical significance equal to or greater than one from Germany household consumption data. In contrast, emissions fall even with a zero or negative income elasticity. Consequently, a positive income elasticity of demand for environmental improvement goods is neither a necessary nor a sufficient condition for the EKC hypothesis to hold according to McConnell. While the elasticity analysis does not explain the inverted-U EKC hypothesis completely in empirical studies, even in high income countries, scholars have attempted to utilize neoclassical marginal analysis in explaining the EKC hypothesis (Prizzia, 2002; Smulders et al., 2005; Spangenberg, 2001; Tullock, 2005; Wills, 1998).

**Neoclassical marginal analysis.** The neoclassical environmental growth theory proposes that not all pollution could, would, or should be completely controlled (Prizza, 2002; Spangenberg, 2001, Tullock, 2005; Wills, 1998). Neoclassical marginal economists suggest that "pollution and natural resource degradation are to be controlled to the point where the marginal (social) revenues equal to marginal (social) cost of abatement" (Prizzia, 2002, p. 317). This is otherwise referred to as the optimal level of environmental protection (Prizzia, 2002). From this point of view, the optimal level of environmental protection follows an equilibrium expansion path, where marginal utility is equal to marginal cost at different GDP per capita. This expansion path, therefore, formed the EKC. In other words, the EKC is a set of equilibriums between marginal social utility and marginal social production (cost) functions for an economy (Andreoni & Levinson, 2001; Prizzia, 2002).
Both marginal social utility function (also known as named consumption function) and marginal social production (cost) function are surprised by two well-known effects—substitution effects and income ((Prizza, 2002; Spangenberg, 2001, Tullock, 2005; Wills, 1998). The substitution effect is positive, as it increases both consumption and production functions no matter what the level of income may be, leading to environmental deterioration. In contrast, the income effect can positively or negatively affect environment deterioration. At the low-income level, the income effect worsens the environment, but at the high-income level it improves the environment (Panayotou, 2000). The interactions of substitution and income effects direct the environment to deterioration when a country is at a low-income level. In contrast, the income effect dominates at high-income levels, and the environment improves. An inverted-U shaped EKC is generated by the interplay of substitution and income effects as income varies according to neoclassical marginal analysis (Smulders et al., 2005; Panayotou, 2000).

In empirical studies, the neoclassical marginal analysis might arise some problems. First, this analysis combines utility function, production function, and their interaction within a country. Most veteran and operative abatement technologies cannot prevent pollution from increasing if consumers do not employ enough environmental abatement measures as their incomes increase (Plassmann & Khanna, 2003). In other words, income increases do not necessarily abate environmental deterioration unless enough environment-friendly goods are used. Secondly, the neoclassical marginal analysis pays no regard to any factors related to environment deterioration except incomes. Factors like energy efficiency, environmental regulations, governmental fiscal policies for environmental improvement spending, population, foreign direct investment, and
technology improvement are exogenous variables in this analysis. Therefore, the neoclassical marginal analysis is limited in its application on both overtime and cross-countries comparisons and factorial analysis of environmental deterioration issues.

It is beneficial to examine how environmental goods and services are produced and consumed according to the EKC hypothesis from the microeconomic perspective. Microeconomic analysis regards environmental quality as one of the goods or services which can be traded, produced, and centralized on an equilibrium point when demand is equal to supply through interaction of the customer’s utility and the producers’ production functions. This analysis is based on the EKC theoretical framework as well as empirical basis of researchers inquiring into the EKC hypothesis. Microeconomic analysis in the EKC hypothesis focuses on income only. As a result, this analysis ignores the possible effects of other variables, such as technology improvement, technology diffusion through foreign direct investment, and regulation and substitution issues. This limits its practical applicability in the real world.

**Macroeconomic Analysis**

Emerging review and arguments related to the EKC hypothesis have arisen as a result of the availability of a greater number of economic and socioeconomic variables in research. These arguments suggest an enriched and varied inverted curvilinear relationship between environmental deterioration and economic growth (Gidding, Hopwood, & O’Brien, 2002; Iwami, 2001; Stern, 2004b; Turnock, 2000). From the point of view of macroeconomic analysis there were two key propositions, trade liberalization and foreign direct investment, in explaining the EKC hypothesis. Both trade liberalization and foreign direct investment analysis believed that higher income
countries scatter pollution-intensive products to lower income countries with lower environmental standards, either through trade or through direct investment in these lower income countries (Ansuategi & Perrings, 2000; Nordström & Vaughan, 1999). These two analyses involved two major assumptions. First, the time preferences of environmental-friendly goods and discount rates on environmental deterioration are different in different income countries. That is, less developed economies were more willing to “discount future and geographically distant effects to [encourage] current economic activity” (Ansuategi & Perrings, 2000, p. 335). Secondly, less developed or income countries can only afford a lower scope of environmental regulation because “the larger the scope [regulations] of the institution [or countries], the higher the transaction cost and the more binding the feasibility [on economic growth] constraints” (Ansuategi & Perrings, 2000, p. 356).

**Trade liberalization analysis.** Classical economic analysis on the relationship between trade liberalization and environmental deterioration was based on the comparative advantage trade theory, which was founded by David Ricardo in late 18th century (Muradin & Martinez-Alier, 2001). Based on comparative advantage theory, it assumed that there were different environmental standards and different abilities for resource treatment between trading countries (Muradin & Martinez-Alier, 2001). These assumptions, in turn, were associated with different income per capita in the trading countries with a higher income than in countries adopting stricter environmental standards and utilizing better resource treatment abilities (Ansuategi, 2003; Copeland & Taylor, 1994; Copeland & Taylor, 2004). Essentially, trade affects the environment through the interaction of three elements—the composition effect, the scale effect, and
the technique effect (Botcheva-Andonova, Mansfield, & Milner, 2006; Copeland & Taylor, 2004).

The composition effect provided benefits in a given economy through increased efficiency and economies of scale in production because of specialization. The net composition effect in a domestic environment improves as export sectors pollute less on an average than import sectors, and deteriorates when the opposite was true (Botcheva-Andonva et al., 2006; Copeland & Taylor, 2004). The problem was that not all countries can specialize in industries that are inherently less polluting, because one country’s exports are another country’s imports. International trade hence redistributes domestic environmental deterioration problems in the world from countries that have a comparative advantage in inherently less polluting industries to countries that have a comparative advantage in inherently more polluting industries (Botcheva-Andonva et al., 2006; Copeland & Taylor, 2004).

The scale effect has ambiguous effects on environmental deterioration. On one hand, the scale effect has a positive correlation with environment deterioration, since the more the production in economic activity, the lesser is the environmental quality if the production is given (Ansuategi & Perring, 2000; Copeland & Taylor, 2004). On the other hand, the silver lining of the scale effect is that income growth is associated with a greater willingness to pay for a cleaner environment, which results in reducing environmental deterioration (Copeland & Taylor, 2004).

Simultaneously, along with income growth, not only do polluting goods become more undesirable for consumers, they also become also more expensive through higher regulation standards. The interaction between consumers’ desire for better environment
and regulations leading to technological improvement in abating both pollution flows and sources is known as the technique effect (Smulders, Bretschger, & Egli, 2005). In other words, the techniques effect will lessen environmental deterioration.

The net result of environmental impact from international trade depends on the components of composition, scale, and techniques effects. Theoretically, the technique effect neutralizes the scale effect, but empirically, it does not neutralize both the composition and scale effects because of lax environmental regulations in less-developed countries (Botcheva-Andonova et al., 2006; Copeland & Taylor, 1994). The main problem of the comparative advantage of trade theory in explaining environmental deterioration is that environmental standards should not be the only cause for comparative advantage, because abatement costs are only a small part of production costs according to empirical analysis (Botcheva-Andonova et al., 2006; Nordström & Vaughan, 1999). Other factors, such as labor cost, transportation cost, taxes and subsidies, which induce comparative advantage, could easily cover the small cost differences (Copeland & Taylor, 1994; Copeland & Taylor, 2004; Mabey & Richard, 1998; Nordström & Vaughan, 1999).

Part of the problem might arise when applying comparative advantage trade theory. The theory focused only on two inputs—capital and labor only. A higher capital-labor ratio created a comparative advantage in capital intensive merchandise, and vice versa (Botcheva-Andonova et al., 2006). If other conditions stay the same in a country that has comparative advantage in capital-intensive industries—such as pulp, paper, iron, and steel, which inherently pollute the most—then the environment quality in these countries, developed countries in general, will worsen due to specialization in production of pulp,
paper, iron, and steel industries. According to the comparative advantage theory, labor-intensive countries, which were normally developing countries, would improve environmental quality by specializing in the production of labor-intensive productions that inherently pollute less (Botcheva-Andonova et al., 2006; Copeland & Taylor, 1994).

That is, neither developed nor do the developing countries necessarily experience decreased pollution. International trade, therefore, changed the composition of production, causing more pollution in some (not necessarily in developing) countries and less pollution in other (not necessarily developed) countries (Botcheva-Andonova et al., 2006; Copeland & Taylor, 1994). There was no simple one-to-one algebraic equation that reflects the relationship between trade and environmental deterioration. All the results were highly depended on assumptions about trade conditions. Besides, in the long run, a dynamic and constantly evolving analysis, such as that proposed by the EKC hypothesis, was complicated, since comparative advantages were not static or always given (Nordström & Vaughan, 1999). Whether, therefore, all countries gained environmental benefits through international trade were uncertain. What was clear was that pollution can transfer from one country to another through trade and specialization in production.

Investigations of the relationship between trade liberalization and environmental deterioration resulted in ambiguous findings in empirical studies (Archibald, Banu, & Bochniarz, 2004; Boyce, 2004; Iwami, 2001; Nordström & Vaughan, 1999; Perroni & Wigle, 1994; Radej & Zakotnik, 2003). Archibal et al. (2004), Boyce (2004), and Radej and Zakotnik (2003) proposed no immobility relationship between international trade and environmental deterioration. They found that the relationship between environmental
quality and trade was not only involved in producing inputs and technology process, but also had come with regulations and governance efficiency. Iwami (2001) indicated that trade has increased the burdens on the environment in eight Southeast Asian countries. Even though environmental deterioration occurred in Southeast Asian countries, Iwami did not think it would necessarily occur in other late-industrialized countries, especially ex-socialist countries. Iwami believed that liberalization in foreign trade has pressed the ex-socialist countries’ state-owned firms towards more efficiency in energy consumption for survival. In other words, Iwami implied that economic background played one of the key issues in debating the relationship between trade liberalization and environmental deterioration.

Radej and Zakotnik (2003) examined and projected the influences of export competitiveness and specialization on the environment from 1989 to 2006 in Slovenia, a transitional country. Their conclusions were in agreement with comparative advantage theory. Environmental quality was an interactive result of scale effect and composition effect. The environmental quality of Slovenia was better than it had been at the beginning of transition because Slovenia had to focus on natural resource-intensive and unskilled labor-intensive products, which caused relatively low pollution. On the other hand, the retardation of economic activities at the beginning of economic reform in Slovenia resulted in less pollution than before. This trend became unclear after 1998, when Slovenia’s export products become more technology-intensive, capital-intensive, and higher-pollution process products were traded. Even Slovenia’s environmental quality turned worse after 1998; however, in total Radej and Zakotnik believed that
Slovenia benefited in environmental quality from environmentally-advanced trade partners via the liberalization of trade.

The advantage of Radej and Zakotnik (2003) was that they sourced aggregate pollution from inputs of exports and types of exports, natural resource-intensive products, unskilled labor-intensive products, technology-intensive products, and human capital-intensive products and their inputs. There were, however, disadvantages to Radej and Zakotnik's work. First, their inquiry involved the manufacturing sector only. Factors such as environmental regulations, income level, foreign direct investment, and energy efficiency are suggested for future studies regarding decomposition of the changes in pollution. Secondly, Radej and Zakotnik conducted air emissions only, and it is unclear whether other environmental issues, such as desertification, deforestation, and so on, were improved in Slovenia at the same time. Environmental deterioration might switch from one element, such as air, to another, such as desertification, at times (York et al, 2003). Finally, since Slovenia was one of the most advanced and richest transitional countries in an ex-socialist society (The World Bank, 2006), further evidence was required to determine whether the same experiences occurred in other transitional economies.

**Foreign direct investment analysis.** Scholars utilized a similar theoretical analysis path as that used in debating trade liberalization on environmental issues to explain the effects of foreign direct investment on environmental quality (Botcheva-Andonva et al., 2006; Mabey & McNally, 1998). Three hypotheses—the pollution havens hypothesis, the pollution halos effects hypothesis, and the race-to-the-bottom hypothesis—were
addressed particularly in analyzing foreign direct investment on environmental issues (Mabey & McNally, 1998; Radej & Zakotnik, 2003; Yandle et al., 2004).

1. **Pollution havens hypothesis.** The key assumption of this hypothesis was that there are different environmental standards between host and source (investor) countries. Therefore, companies will move operations to countries with lax environmental standards, which are normally developing or less-developed countries, to take advantage of less stringent environmental regulations. In this way, firms are still “allowed to continue their pollution” (Yandle et al., 2004, p.14). As a result, countries with lax environmental standards will attract firms that cannot fulfill higher environmental regulations domestically. This hypothesis implies that more foreign direct investment will weaken the environment in host countries as long as regulation gaps exist (Mabey & McNally, 1998; Yandle et al., 2004).

2. **Pollution halos hypothesis.** Klavens and Zamarutti (1995), Mabey and McNally (1998), and Radej & Zakotnik (2003) provided evidence in opposition to the pollution havens hypothesis. They argued that foreign direct investment could result in the introduction of less-polluting technologies, training, and skills, which have not yet been developed domestically, to benefit host countries. Eskeland and Harrison (1997) found that foreign direct investment that was positively associated with GDP per unit of energy caused less pollution in atmospheric concentrations in Mexico, Venezuela, and Cote d’Ivoire. Liang tested more than 200 major cities in China and found that these
cities benefited from foreign direct investment by increasing in GDP per unit of energy use.

3. Race-to-the-bottom hypothesis. By way of empirical research in formal communist economies, Klavens and Zamparutti (1995) concluded that most foreign investors look ahead at environmental issues when make investment decisions in less-developed or developing countries. They found, in fact, that most foreign investors maximize volumes of pollution to meet the minimum requirements of host countries’ environmental standards in transitional economies, even if foreign investors introduce advanced pollution control technologies in host countries. This phenomenon is known as the race-to-the-bottom hypothesis (Mabey & McNally, 1998; Zarsk, 1999). Iwami (2001), Radej and Zakotnik (2003), and Zarsky (1999) confirmed that host countries, usually less developed or developing countries, must reduce environmental standards to encourage foreign direct investment and to enlarge comparative competitive advantage in global markets or for the purpose of stimulating domestic growth.

From a theoretical point of view, the pollution havens hypothesis has strong theoretical underpinnings of neoclassical comparative advantage economics analysis (Ansuategi & Perrings, 2000; Mabey & McNally, 1998). From an empirical point of view, the race-to-the-bottom phenomenon might happen in some less-developed countries with lax environmental regulations that are in the middle phase of economic development (Ansuategi & Perrings, 2000; Iwami, 2001). The race-to-the-bottom does
not have sufficient evidence, however, to confirm that environmental deterioration will happen in all host countries (Ansuategi & Perrings, 2000).

Empirical Studies in CEE and SEA

CEE countries. The issue of environmental deterioration in CEE countries has been well documented by scholars of trade liberalization, foreign direct investment, economic efficiency, and regulatory structure, with diverse conclusions (Archibald et al., 2004; Botcheva-Archibald et al., 2006, Kukla-Gryz & Zylicz, 2004; Vukina, Beghin, & Solakoglu, 1996). Botcheva-Archibald et al. (2006) believed that the race-to-the-bottom relationship between economic growth and environmental deterioration was unavoidable in CEE. Kukla-Gryz and Zylicz (2004) concluded that the CEE still has to clean up the heritage of pollution left from ex-socialism society, even with the improvements in the environment. Botcheva-Archibald et al. (2006) categorized 25 transitional economies into four type of liberalizers—early liberalizers, late liberalizers, additional late liberalizers, and non-liberalizers. They found that market liberalization, stabilization, and institutional reforms could positively influence environmental quality significantly for early liberalizers and late liberalizers but that this was not the case for additional late liberalizers and non-liberalizers.

Kukla-Gryz and Zylicz (2004) conducted a study to estimate the EKC for the ten countries that joined European Union (EU) in 2004. They assessed whether these ten new EU members would replicate the EKC trajectories of old EU members. Unlike the inverted-U relationship between emissions and economic growth in old EU members, Kukla-Gryz and Zylicz could not find a linear relationship between economic growth and CO₂ emission in new EU members from 1989 to 2001. “[T]he heritage of central
planning has been so overwhelming that until now these countries have struggled to achieve ‘pollution intensities’ of GDP characteristic for market economies” (Kukla-Gryz and Zylic 2004, p. 18), they concluded.

Statistic analysis by Kukla-Gryz and Zylic (2004) was addressed adequately by utilizing Feasible Generalized Least Squares in reflecting autocorrelation and heteroscedasticity problems. Yet the literature review of their study was insufficient—in fact, one can hardly find literature review in their study—to connect the environmental problems and the economic growth background of CEE with their research problem area. The research methods section was confusing in Kukla-Gryz and Zylic (2004). For unknown reasons, the authors have chosen a sample of eight rather than ten EU members in their methods. Moreover, they adapt two theories—the IPAT model and the EKC model—without addressing them in their analysis. There is neither an explanation nor a comparison presented as to why the researchers simultaneously utilized these two technological econometric tools as their framework for analysis.

The scope of variables was another area of inquiry. Bluffston and Panayotou (1997), Radej and Zakotnik (2003), Smith and Hills (2003) proved that economy and environment were sensitive to international trade, foreign direct investment, regulations, and technological diffusion in these new EU members. Unfortunately, Kukla-Bryz and Zylic’s research did not conduct these important variables.

Kukla-Bryz and Zylic’s (2004) findings were consistent with most research in this area. Kukla-Bryz and Zylic addressed that
All developing and transition economies are pressed to behave in a more environmentally responsible way than developed market economies used to do when they were at comparable income levels some decades ago. (p. 19)

Conscientious and careful review through statistical analysis was still required. A downward sloping of the time series emission curve, as shown in Kukla-Bryz and Zylic (2004) article, did not necessarily reflect a statistical improvement in the environment. Bruvoll and Medin (2003) have addressed the fact that industrial activities in the new EU members have decreased dramatically since they reoriented to market economy. Therefore, decreases in emissions did not necessary imply improvement in the environment; instead, this might indicate that less energy has been consumed due to less industrial activity by these new EU members, especially at the beginning years of transition.

Kukla-Gryz and Zylic (2004) concluded that it would have been impossible to obtain an inverted-U EKC in the new EU members because these countries were still cleaning up the pollution that was inherited from their histories as formal communist societies. That is, the new EU members did not replicate the development trajectories of old EU members, according to Kukla-Gryz and Zylic. If this is true, the question will be raised as to whether the new EU members, which are transitional economies, have better environmental performance than other non-transitional economies with similar income levels for future inquiry.

**SEA countries.** There were an increasing number of studies that explore the significance of the EKC hypothesis and technological diffusion effects on the relationship between economic growth and environmental protection in developing South and East
Asia (Iwami, 2004, 2005; Show et al., 2004). Literature regarding environmental issues in this region focused on the existence of EKC and the technology diffusion effect (Iwami, 2004, 2005; Mathews, 2002; Ozawa, 2004; Show et al., 2004).

Iwami (2004) measured the emissions of CO$_2$ and SO$_2$ in China, Indonesia, Japan, Korea, Malaysia, the Philippines, Singapore, Taiwan, and Thailand. These findings suggested the inverted-U relationship between economic growth and environmental quality, utilizing ordinary least square analysis of panel data analysis (Iwami, 2004). Iwami's interpretation of these findings of the East Asian countries follows the EKC hypothesis, as well as previous studies in OECD and European countries (Iwami, 2004; Zaim & Taskin, 2000). The turning points of CO$_2$ and SO$_2$ were around 38,000 and 29,000, respectively, in constant 1997 US dollars.

The strength of Iwami's work (2004) was the presentation of a typical inverted-U EKC, which anticipates that the whole of a country's CO$_2$ and SO$_2$ emissions would continue to increase if its economic growth rate exceeded the rise in its energy efficiency. One major limitation of Iwami's work was that it ignored the economic backgrounds among investigation countries. Like CEE countries, China was one of the communist central planned economies, which resulted in overindustrialization, misindustrialization, economic inefficiency, and environmental deterioration. Therefore, characteristics of economic backgrounds were suggested in this investigation.

Iwami (2005) has conducted research on the latecomer advantage in abating air pollution in 9 SEA countries. Japan suffered from several different types of industrial pollution during its high-speed but distorted economic growth from the early 1970s (Iwami, 2005). Following in the footsteps of Japan, many SEAs subsequently recorded
remarkable economic achievement by adopting development policies similar to those employed in Japan. However, although SEAs now enjoyed a comparable income to that enjoyed by Japan in the early 1970s, their air pollution was less severe than it has been in Japan (Iwami, 2004, 2005). Governmental regulations, technology diffusion from advanced countries, and the learning effects of industries in developing economies were major reasons why SEAs enjoy better economic and environmental performances (Iwami, 2005).

Iwami’s results (2005) were unexpected. Iwami pointed out that not all latecomer economies would benefit from the advantage of being latecomers. Only those countries with latest-comer status, namely Indonesia, Malaysia, and Thailand, could benefit from being latecomers in their industrialization expansions (Iwami, 2005). The medium latecomers, including the Korean Republic, the Philippines, and Singapore, were statistically not significant in the benefits they gained from new technology in the environmental deterioration abating issues (Iwami, 2005).

However, some issues of Iwami (2005) required further discussion. First of all, Iwami classified the latecomers into three levels of latecomer status—latest comer, medium latecomer, and predecessors according to industrial sector index, which was industrial sector to GDP in 1990 divided by that in 1973. Latest comer was a classification for those SEAs with an index larger than 1.5. Medium latecomer represented SEAs with an index larger than or equal to 1, but less than or equal to 1.5. Countries with an index of less than 1 are represented as predecessors. Iwami did not explain why 1 or 1.5 was chosen as the grouping standard in either a theoretical or empirical framework. As a result of this grouping standard, one unexpected consequence
was that China was characterized as a predecessor rather than a medium latecomer or latest comer in environmental deterioration issues. Although Iwami argued that the predecessor was not necessarily equal to the advancer either in extending economic development or in abating environmental impact, this debate lacks, or perhaps outright contradicts, the theoretical and empirical foundation (Inotai, 1995).

Another question was why the latest comer could gain by learning from leading countries' experiences, while the medium latecomer cannot gain from this. Regrettably, there was no clear explanation in Iwami's (2005) investigation. Perkins and Neumayer (2005), from a capital stock point of view, provided a possible answer to this question. Perkins and Neumayer pointed out that many late-industrialization countries, usually developing countries, can opt for competing new technologies based on their expected returns, whereas early industrialization countries have already made significant capital investment. Due to non-recoverable sunk costs theory, early industrialization economies may find out it was more profitable to continue using existing less-efficient instruments than to replace them with new more efficient plants and equipments (Perkins & Neumayer, 2005).

Discussion of the Literature

Summary and Interpretations

The purpose of this critical analysis of theoretical and empirical literature review of country characteristics, economic growth, environmental quality, and the environmental Kuznets curve hypothesis in CEE and SEA countries was to explore the relationship between economic growth and environmental deterioration. A major finding of this literature review was that the relationship between economic growth and
environmental deterioration was not fixed. The relationship might change direction from positive to negative along with economic expansion. This relationship was known as EKC hypothesis.

Emerging theories and models have enriched and diversified the EKC hypothesis. GDP per unit energy use, secondary industry to GDP, foreign direct investment, and international trade are major factors shifting and dumping the EKC. The following two sections were a theoretical and empirical literature review, aiming for a synopsis of the state-of-the-art theoretical and empirical literature about the topic and letting the reader know what is known and unknown.

Theoretical Literature

Microeconomic analysis. Some researchers utilized elasticity analysis to interoperate environmental deterioration (Antle & Heidebrink, 1995; Hökby & Söderqvist, 2003; Israel & Levinson, 2004). They suggested that a growth in income led to environmental deterioration at low-income level because environmental protection was at low priority. The income elasticity of environmentally friendly goods was less than 1 at this stage. At a later stage, when incomes grow to a certain level, demands for environmental protection increased, leaded to an expansion in both economic development and environmental improvement. The income elasticity of environmentally friendly goods was greater than 1 in this stage. Therefore, an inverted-U shape of EKC was formed.

Neoclassical environmental economists utilized neoclassical marginal analysis to propose that not all pollution, as externalities, could or would be entirely controlled, nor was all natural resource degradation fully reversed (Prizzia, 2002; Tullock, 2005).
Therefore, marginal analysis suggested that environmental quality and natural resource degradation should be controlled to the point where the marginal social revenue equaled the marginal social cost—what was also called the *optimal level of environmental protection* analysis (Prizza, 2002). That is, the EKC was a set of equilibriums between marginal social revenue and marginal social cost functions (Andreoni & Levinson, 2001; Prizza, 2002).

The major limitation of microeconomic analysis was that this analysis considered income as the only variable in explaining environmental deterioration. Other variables, such as industrialization, energy efficiency, were exogenous.

**Macroeconomic analysis.** When income per capita was relatively low, people were more willing to trade environmental deterioration for economic growth, due to the tendency of humankind to discount future and geographically distant effects in favor of current economic activity (Ansuategi & Perrings, 2000). Panayotou (2000) noticed “richer countries... spin-off pollution-intensive products to poor countries ... with ... lower environmental standards, either through trade or direct investment in these countries” (p. 16). In other words, macroeconomic environmental research from international trade and foreign direct investment point of views interpreted the environmental and economic relationship, especially in developing or less developed countries.

Comparative advantage theory provided the theoretical foundations of international trade liberalization and foreign direct investment on environmental deterioration (Muradin & Martinez-Alier, 2001). It was assumed that there are different environmental standards and different abilities for resources treatment between trading and investing.
countries (Muradin & Martinez-Alier, 2001). Therefore, neither all trading partner countries nor all investing parties could improve their environmental quality from trading or investing. *Pollution havens, pollution halos, and race-to-the-bottom hypotheses* were the major hypotheses used to examine environmental improvement among trading or investing countries.

The macroeconomic analysis model involved preference of consumers’ choices, international trades, and foreign direct investments. The difference between microeconomic and macroeconomic analysis was that macroeconomic analysis conducts interaction between countries instead of single economic activities in a specific country only. However, the limitation of this macroeconomic comparative advantage was that trading or investing parties were highly dependent on the relative prices of pollution-intensive goods, which are higher in high-income countries, and the resource prices differences among countries (Panayotou, 2000). The effects of comparative advantage theory on environmental issues would not work unless this assumption holds.

**Empirical Literature**

**Microeconomic analysis.** Empirical studies on elasticity analysis failed to prove that the income elasticity of environmentally friendly goods was greater than 1 (Carson, Flores, Martin, & Wright, 1994; Hökby & Söderqvist, 2003; Kristöm, 1995; Pearce & Palmer, 2001). Hökby and Söderqvist (2003) conducted an inquiry into the elasticities of demand and willingness to pay for environmental services in Sweden; they found that the income elasticity of most environmental services was greater than 0 but less than 1, even when the income level was beyond the turning point of EKC. Pearce and Palmer (2001) tested the role of income elasticity on willingness to pay for environmental services in
OECD countries, and concluded an elasticity of 1.2, which was far less than expected if the downward sloping part of EKC existed (Pearce & Palmer, 2001). McConnell (1997) found that the income elasticity of environmentally friendly goods even fell to negatives in Germany.

**Macroeconomic analysis.** Radej and Zakotnik (2003) examined the relationship between international trade and environmental deterioration in Slovenia. Their analysis showed that pollution emissions linked to international trade would increase by 22% between the year 2000 and 2006. Three hypotheses, *pollution havens hypothesis*, *pollution halos effects hypothesis*, and *race-to-the-bottom hypothesis*, were utilized in most empirical research regarding the effects of foreign direct investment on environmental deterioration (Mabey & McNally, 1998; Radej & Zakotnik, 2003; Yandle et al., 2004). Eskeland and Harrison (1997) and Liang (2005) found that foreign direct investment positively associated with GDP per unit of energy caused less pollution in Mexico, Venezuela, and Cote d'Ivoire and more than 200 major cities in China. Botcheva-Archibald et al. (2006) and Kukla-Gryz and Zylicz (2004) believed that the race-to-the-bottom phenomenon in environmental deterioration in the CEE was unavoidable. Iwami (2001), Radej and Zakotnik (2003), and Zarsky (1999) confirmed the phenomenon of the pollution haven hypothesis, because less-developed or developing countries have to reduce environmental standards in order to encourage foreign direct investment and to enlarge the comparative competitive advantage in global markets for the purpose of stimulating domestic growth.

Kukla-Gryz and Zylicz (2004) concluded the CEE was yet to clean up the heritage of pollution left from ex-socialism society, even with the improvement in the
environment. Therefore, they failed to conform to EKC in CEE. Iwami (2004) measured the emissions of \( \text{CO}_2 \) and \( \text{SO}_2 \) in nine SEA countries and conformed to the inverted-U relationship between economic growth and environmental deterioration in this area. Technology diffusion and learning effects, moreover, were factors for better environmental quality in latecomer countries (Iwami, 2005).

Most of the empirical investigations related to environment and economic growth were regressed equations related to an environmental impact indicator, such as \( \text{CO}_2 \), \( \text{SO}_2 \), CFC or \( \text{NO}_2 \), on income per capita and other specification variables, such as energy efficiency, industrialization, and international trade. However, a characteristic that makes the CEE countries different from other countries is that they are based on a transitional economic system. Most previous literature reviews did not consider these countries' economic system to be different. A suggested supplement to the empirical study is a decomposition of the effects of economic system change, keyed into its environmental quality.

**Conclusions**

The concept of better environmental quality has emerged as a paradigm recently. From the economic dimension in particular, the frequently used EKC hypothesis depicts a tradeoff relationship between environmental degeneration and economic development, providing a “grow first, then clean up” stage for policymakers in developing and less-developed countries (Dasgupta et al, 2002, p. 147). Literature in economic-environmental theory addressed the following three key concepts (Panayotou, 2000):

1. The EKC hypothesis was supported by microeconomic and macroeconomic theories with specification assumptions;
2. Models in explained environmental degeneration were dependent on functions of revenue, cost, production, and comparative advantage among countries;

3. The EKC hypothesis assumed that government, consumers, and producers would, could, and will achieve a better environment as long as income increases.

The empirical literature of the economic-environmental relationship presented the following three pieces of evidence:

1. The relationship between environmental deterioration and economic growth was not fixed along a country's economic development path;

2. Most of the emissions fulfilled the inverted-U curve relationship between environmental deterioration and economic in developed countries. However, it did find in some developing countries—i.e., SEA—but failed to find the inverted-U EKC in CEE.

3. Empirical investigations related to environment and growth usually resulted in a single reduced form equation relating to an environmental impact indicator, as well as income per capita, population, industrialization, and trade liberalization.

**Recommendations**

Current literature cited many economic variables from a number of countries with varying income levels in order to show the relationship between environmental deterioration and economic growth. It alluded specifically or implicitly to high-income OECD countries, transitional CEE economics, and non-transitional SEA countries, but did not compare similar incomes with different economic background into a model. In
other words, the gap was that no literature facilitates a comparison of the relationship of economic growth and environmental deterioration between countries with different economic backgrounds—transitional CEE countries and non-transitional SEA economies—but similar income levels. This research attempted to achieve this objective. The purpose of this research, therefore, was to conduct an explanatory (correlational) and comparative study of the relationship of economic growth and environmental deterioration in countries with similar income per capita but different economic backgrounds: SEA, i.e. non-transitional, and CEE, i.e. transitional, countries.

**Summary of Chapter II**

The context of the literature review arose out of existing theoretical and empirical studies in the area of economic growth and environmental deterioration and paved the road for future research. The significance of this chapter was its presentation of what has been both examined and unexamined in previous studies, which led to the investigation of unique research questions and the testing of various hypotheses. Chapter II has cited literature that dealt with environmental deterioration and economic growth using the EKC hypothesis, GDP per unit of energy use, secondary industrial sector to GDP, foreign direct investment, and international trade. Previous reviews, however, have not dealt with the difference of the relationship between economic growth and environmental deterioration while considering economic background as a factor. A predominantly explanatory study of environmental deterioration of CEE’s transitional economies and SEA’s non-transitional economies was conducted in Chapter II. Chapter III described a methodology to investigate the topic, the questions, and hypotheses founded upon this chapter.
CHAPTER III
RESEARCH METHODS

Based on the critical analysis of theoretical and empirical literature, this chapter extended the previous two chapters in order to describe research methods used to examine the relationship between economic growth and environmental deterioration in CEE and SEA countries. Chapter II identified the key gap in existing literature—the lack of a comparison of the relationship of economic growth and environmental deterioration in countries different economic backgrounds but similar income level countries. Chapter III began with an introduction of research questions and hypotheses, and then elaborated on a research methodology which included the specific research design, population, sampling plan and setting, measurement tool, and data analysis in this study. An evaluation of the research was conducted at the end of this chapter.

Theoretical Framework for the Study

The major theory guiding this study of the economic growth and environmental deterioration of CEE and SEA countries was based on the Environmental Kuznets Curve (EKC) hypothesis developed by The World Bank in 1992 (Dasgupta et al., 2002; Panayotou, 1995; Stern, 2004a, 2004b). More and more emerging reviews and arguments related to the EKC hypothesis arose as a result of the availability of a greater number of economic variables, suggested an enriched and varied inverted-U curvilinear relationship between environmental deterioration and economic growth (Gidding, Hopwood & O’Brien, 2002; Iwami, 2001; Stern, 2004a; Turnock, 2000). Recently in analyzing environmental quality, economists have begun to examine factors such as
economic structure, industrialization, and global linkage as factors affected the environment (Bruvoll & Medin, 2003; Panayotou, 2000; Zaim & Taskin, 2000).

This study, therefore, combined the global linkage (foreign direct investment and international trade), industrialization (GDP per unit of energy use and secondary industry to GDP), and income per capita as factors in explaining the differences in environmental deterioration in different economic background countries. Simultaneously, this investigation examined whether economic background affects the relationship between environmental deterioration and economic growth. The significance of this study was its examination, comparison, and testing of what factors lead to environmental deterioration in transitional and non-transitional economies. Figure 3-1 showed the theoretical framework of this study.
Research Questions

1. What are the macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and per capita emissions (CO$_2$ and SO$_2$) of CEE and SEA countries from 1990 to 2006, or the most recent data available?
2. What are the over time percentage changes in macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and percentage changes in per capita emissions (CO₂ and SO₂) of CEE and SEA countries from 1990 to 2006, or the most recent data available?

3. What are the differences in macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and per capita emissions (CO₂ and SO₂) of CEE versus SEA countries from 1990 to 2006, or the most recent data available?

**Research Hypotheses**

H1: There is a significant curvilinear explanatory relationship among macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and per capita emissions (CO₂ and SO₂) in the CEE countries from 1990 to 2006, or the most recent data available.

H₁ₐ: There is a significant curvilinear explanatory relationship among macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and per capita CO₂ emissions in CEE countries from 1990 to 2003, which is the most recent data available.

H₁₅: There is a significant curvilinear explanatory relationship among macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade)
and per capita SO₂ emissions in CEE countries from 1990 to 2002, which is
the most recent data available.

H2: There is a significant curvilinear explanatory relationship among macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and per capita emissions (CO₂ and SO₂) in the SEA countries from 1990 to 2006, or the most recent data available.

H2ₐ: There is a significant curvilinear explanatory relationship among macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and per capita CO₂ emissions in SEA countries from 1990 to 2003, which is the most recent data available.

H2ₗ: There is a significant curvilinear explanatory relationship among macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and per capita SO₂ emissions in SEA countries from 1990 to 2000, which is the most recent data available.

H3: There is a significant curvilinear explanatory relationship among the percentage change in macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and the percentage change in per capita emissions (CO₂ and SO₂) of CEE countries from 1990 to 2006, or the most recent data available.

H3ₐ: There is a significant curvilinear explanatory relationship among the percentage change in macroeconomic indicators (GDP per capita, GDP per
unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and the percentage change in per capita CO₂ emissions in CEE countries from 1990 to 2003, which is the most recent data available.

H₃₅: There is a significant curvilinear explanatory relationship among the percentage change in macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and the percentage change in per capita SO₂ emissions in CEE countries from 1990 to 2002, which is the most recent data available.

H₄: There is a significant curvilinear explanatory relationship among the percentage change in macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and the percentage change in per capita emissions (CO₂ and SO₂) of SEA countries from 1990 to 2006, or the most recent data available.

H₄₅: There is a significant curvilinear explanatory relationship among the percentage change in macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and the percentage change in per capita CO₂ emissions in SEA countries from 1990 to 2003, which is the most recent data available.

H₄₆: There is a significant curvilinear explanatory relationship among the percentage change of macroeconomic indicators (GDP per capita, GDP per
unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and the percentage change in per capita SO$_2$ emissions in SEA countries from 1990 to 2000, which is the most recent data available.

H5: The percentage change in macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and country categories (transitional countries, CEE, and non-transitional countries, SEA) are significant explanatory variables of the percentage change in per capita emissions (CO$_2$ and SO$_2$) from 1990 to 2006, or the most recent data available.

H5$_a$: The percentage change in macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and country categories (transitional countries, CEE, and non-transitional countries, SEA) are significant explanatory variables of the percentage change in per capita CO$_2$ emissions from 1990 to 2003, which is the most recent data available.

H5$_b$: The percentage change in macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and country categories (transitional countries, CEE, and non-transitional countries, SEA) are significant explanatory variables of the percentage change in per capita SO$_2$ emissions from 1990 to 2000, which is the most recent data available.
H6: There are significantly fewer per capita emissions (CO₂ and SO₂) in CEE countries than that in SEA countries from 1990 to 2006, or the most recent data available.

H6a: There is a significantly fewer per capita CO₂ emission in CEE countries than that in SEA from 1990 to 2003, which is the most recent data available.

H6b: There is a significantly fewer per capita SO₂ emission in CEE countries than that in SEA from 1990 to 2000, which is the most recent data available.

In order to have a clear picture regarding the hypotheses being tested in this study, Figure 3-2 presents the hypothesized relationships in the literature and those that are being tested in this inquiry.
Hypothesized relationship in literature

Hypothesized relationship being tested

Figure 3-2. Hypothesized relationships.
Methodology

A quantitative, non-experimental, correlational (explanatory), causal-comparative, cross-country time series secondary research design was used in this investigation. The entire population of economic and environmental indicators in the eight CEE and six SEA countries include Czech Republic, Estonia, Hungary, Indonesia, the Korean Republic, Latvia, Lithuania, Malaysia, the Philippines, Poland, Singapore, Slovak, Slovenia, and Thailand. Secondary data in the form of World Development Indicators from The World Bank group is a significant database. All the data are sourced from the World Development Indicators database except data on per capita SO₂, which is sourced from Stern (2005).

The explanatory variables included GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment to GDP, international trade to GDP, and country categories, a dummy variable with CEE equal to 1 and SEA equal to 0. The dependent variables were emissions per capita of CO₂ and SO₂. However, not all variables were utilized simultaneously in all hypotheses testing. Independent and dependent variables varied with respective hypotheses. Descriptive statistics (over time frequency distributions, measures of central tendency, and variability) were applied to answer research questions 1 to 5. Linear regression analysis was applied for hypotheses 1 to 5. An independent t-tests was used to test for hypothesis 6.

Research Design

A quantitative, non-experimental, correlational (explanatory) causal-comparative, cross-sectional and time series secondary research design was utilized to examine the relationship between economic growth and environmental deterioration in CEE and SEA.
countries. The World Development Indicators from The World Bank database and (2005c) were used to answer the research questions and test the hypotheses. The strengths of utilizing secondary data by international organizations were that doing so was inexpensive, consistent, time-saving in terms of data collection, and facilitates credible results, as the data were periodically published by international organizations or institutions. Moreover, specific organizations or people were the only sources that publish certain types of historical statistics, such as SO₂, cross countries (Babbie, 2004; Cavana, Delahaye, & Sekaran, 2000). There were, however, various disadvantages in utilizing secondary data. The secondary data, for example, might lack consistent perspectives, or might feature biases and inaccuracies that cannot be checked; the data can be completely separated from the context of its collection (time-series data are usually separated into different volumes of publications even by the same publisher), might feature different measurement units (GDP in US dollars or in Euro), and might sample from different data sources (sampling from different ages, genders, and regions) (Babbie, 2004; Cavanaugh et al., 2000).

**Population and Sample Plan**

**Target Population**

The target population of this study included data on macroeconomic indicators and emissions of eight CEE and six SEA countries from 1990 to 2006, or the most recent data available. The eight CEE countries—Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovak Republic and Slovenia—were not established until after 1990; therefore, the data covered the years from 1990.
The SEA countries were Indonesia, the Korean Republic, Malaysia, the Philippines, Singapore, and Thailand. The six SEA countries were selected for a number of reasons. First, the SEA was perceived to have similar economic expansion trends to CEE countries, including attracting foreign direct investment and relying heavily on the industrialization, during their development process (Gros & Suhrcke, 2000). Secondly, all of the CEE and SEA countries were either classified as high-income (Singapore, Slovenia, and the Korean Republic) countries or middle-income countries, according to the World Development Indicators (The World Bank, 2006). Finally, these CEE and SEA countries offered a good source of comparison for highlighting the environmental deterioration of countries of similar income levels but different economic backgrounds—transitional CEE and non-transitional SEA countries.

**Accessible Population**

The accessible population is the same as the target population. In this study, there are two explanatory variables, independent and attribute, and one dependent variable. The independent variable included macroeconomic indicators with multiple measures. The attribute variable was the country category. The dependent variable was environmental emissions with multiple measures. Each variable contained 66 to 128 observations from a timeframe of 1990 to 2006 or from the most recent data available. The accessible population of each variable was more than 30 (large sampling), therefore, the observations of this study were justified (Babbie, 2004; Maxim, 1999).

**Sampling Plan**

The entire target population is included in the sample. However, errors or biases are inevitable, due to definition, methodology, units, or bureaucratic quality when
secondary data were adopted. Therefore, data were eliminated from this study that demonstrated a significant change, defined here as 10 times or more, between the previous and the following year for the timeframe of 1990 to 2006.

Measurement

Selected variables measured in this study included macroeconomic indicators, emissions, and country categories. Macroeconomic indicators included GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade. Environmental deterioration included emissions of CO₂ and SO₂. Country categories included two different economic backgrounds groups—CEE, which are transitional countries, and SEA, which are non-transitional countries.

World Development Indicators, published by the World Bank is one of the most important databases. The World Development Indicators included 737 indicators regarding economy, environment, demography, states and markets, and global links worldwide of 226 countries and groups from 1960 to the present (The World Bank, 2007). This study, therefore, used the World Development Indicators, except for emissions of SO₂, as measures to describe and explain the relationship between economic growth and environmental deterioration in CEE and SEA countries.

The World Bank previously provided the per capita SO₂ emission data every other five years; however, they no longer investigate SO₂. Other organizations, such as Eurostat and Asian Development Bank, provided the data for their memberships only. The definitions and calculations of SO₂, furthermore, were verified among Eurostat, Asian Development Bank, and other institutions. Stern's compilation of over-time and cross-country SO₂ emission data, which covered all of the countries in this study from
1850 to 2000, was utilized in this research. A permission letter of utilizing Stern’s SO$_2$ was attached in appendix A.

**Psychometric Issues about Secondary Data Used to Measure Macroeconomic and Emissions Indicators**

Macroeconomic data (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and emissions (CO$_2$ and SO$_2$) were the statistical indicators in this study originating from the World Development Indicators database. Most of the World Development Indicators data came from numerous international organizations, government agencies, and private and non-governmental organizations, including the Carbon Dioxide Information Analysis Center (US), Deutsch Gesellschaft für Technische Zusammenarbeit (Germany), Food and Agriculture Organization (United Nations), International civil Aviation Organization (United Nations), International Labor Organization (United Nations), International Monetary Fund (United Nations), and more than other 20 organizations world widely (The World Bank, 2007).

The data collection and calculations followed agreed-upon guidelines provided by researchers, the World Bank, and its partnership organizations. The Development Data Group in the office of the Development Economics Vice-Presidency is in charge of assimilation, compilation, inventory preparation, archiving, retrieval, and dissemination once data was received (The World Bank, 2007). The choice of indicators for the World Development Indicators has been shaped from staff in the International Finance Corporation, the Multilateral Investment Guarantee Agency, and five of The World Bank’s thematic networks, including Environmental and Socially Sustainable

While statistical indicators are collected by different countries and agencies, the World Bank staff members check the data for consistency, accuracy, and correspondence with the Fundamental Principles of Official Statistics and the Principles Governing International Statistical Activities of the United Nations Statistical Division (The World Bank, 2007). However, differences in methods and conventions may cause discrepancies when comparing data across countries and over time. Therefore, biases or errors are inevitable. The following list outlines some significant psychometric issues when using secondary data, including data from the World Bank, in data analysis (Atlas of Global Inequality, 2006; Babbie, 2004; Goodwin, Nelson, & Harris, 2005)

1. **Units:** Since most macroeconomic or environmental indicators in the World Development Indicators are unitized by country, data users view the world and understand global change through aggregate units and countries, instead of through individual firms or localized areas (The World Bank, 2007). Although aggregate national statistics are valuable in explaining and comparing the changes and differences among countries for different timeframes, aggregate data ignores the diversity within a country (Babbie, 2004). A better indicator would spread across social and economic divides (Babbie, 2004; Maxim, 1999).

2. **Omissions of priorities:** Some data are omitted due to historical reasons. For example, life expectancy, infant mortality, literacy, and other social perspective indices were not collected until 1990. Changes in territories also
introduce problems of omissions. Yugoslavia, for example, was separated into Slovenia, Serbia, and the Republic of Macedonia after 1991.

3. **Definitions:** Errors in methods of data collection arise from inherent differences in operation definitions of variables. For example, GDP and all economic data exclude contributions of that are not monetized. In other words, economic indicators exclude all contributions of housework and crimes because these are non-market behaviors. As a result, drawbacks associated with different operational definitions may bias statistics of production, consumption, labor force and human welfare, as well as other indicators.

4. **Standardization:** Cross-sections, time series data, and country data require standardizing the data and noting exceptions to standards. When there are exceptions, comparability of data sets cannot be ensured, resulting in limitations in interpretations.

5. **Methodology:** Time series, cross-country comparisons usually involve complex statistical questions that must be answered questions that do not answer, which do not have straightforward analytical solutions. Change in a national accounting system is another limitation of utilizing secondary data. The World Development Indicators, for example, uses terminology in line with the 1993 United Nations System of National Accounts, which is different from the definitions of data variables before 1993.

6. **Bureaucratic quality:** The bureaucratic qualities in many developing and under-developed countries are not sophisticated in collecting and computing
even with clear guidelines. This affects the quality, reliability, and validity of the data.

It is clear that errors or biases are inevitable due to definition, methodology, units, or bureaucratic quality. Researchers are advised to consider these limitations when interpreting the indicators from a secondary database, particularly when making comparisons across countries.

**Macroeconomic Indicators**

**GDP Per Capita**

*Description.* GDP per capita is the sum of the gross value added by all resident producers in the economy, plus any product taxed and minus any subsidies not included in the value of products, divided by the midyear population (The World Bank, 2007). GDP per capita is widely cited in various research because it is calculates the production capacity of a country, which makes it the nation’s foremost indicator of a nation’s economic progress (Fisher & Freudenburg, 2004; Goodwin et al., 2005). GDP per capita is now widely used by policymakers, economists, international agencies, and the media as the primary scorecard of a nation’s economic health and well-being (Fisher & Freudenburg, 2004; Goodwin et al., 2005).

*Reliability.* The indicator of GDP per capita from The World Bank was collected and calculated from numerous of organizations all over the world. The collection was done under measurement guidelines published by the Development Data Group in the Development Economics Vice Presidency of The World Bank, designed to measure for consistency and accuracy according to the Fundamental Principles of Official Statistics and the Principles governing International Statistical Activities of the United Nations.
Statistical Division (The World Bank, 2007). Therefore, the GDP per capita has been tested and moderated for reliability.

Any difference in conventions may cause discrepancies in GDP per capita, since it is measured by different countries and agencies. It is quite reasonable to inquire into the reliability of the data. Since the IMF, OECD, the UN, and other trustworthy international organizations either source data from or subordinate or superordinate The World Bank, it was difficult to find any difference in the data among these organizations. To ensure the reliability of the data, the data of GDP per capita were eliminated from this study if it displayed significant shift, defined here as 10 times or more, between the previous or following year within the timeframe of 1990 to 2006 (Iwami, 2005).

**Validity.** Though convergent and discriminate validity of GDP per capita have been established by The World Bank, the data of GDP per capita was calculated without making deduction for depreciation of fabricated assets or for depletion and degradation of natural resources and those that diminish GDP per capita by definition (Fisher & Freudenburg, 2004; Goodwin et al., 2005). GDP per capita, on one hand, excludes non-monetized transactions such as housework and volunteer services. As the non-market economy activities shift to the service sector, the GDP portrays this process as an economic advance. On the other hand, GDP per capita treats every monetized transaction, such as crime, divorce, depletion of natural capital, and natural disaster as economic gain because a transaction of some sort has occurred (Fisher & Freudenburg, 2004; Goodwin, et al., 2005). Therefore, GDP per capita neither reflected real economic activities nor considered actual human welfare.
The Human Development Index, which measures social progress, was launched in 1990 by the United Nations Development Program because of the limitations of GDP per capita. The Human Development Index comprises more than income or production perspectives. It is about creating an environment in which people can develop their full potential and lead productive, creative lives in accordance with their needs and interests (Fisher & Freudenburg, 2004; Goodwin et al., 2005).

Since there was not enough data available in the Human Development Index, its reliability and validity has not been fully established. Today, the GDP per capita is still the master in measuring economic production, even if it creates ceilings (Schiller, 2005).

**GDP per Unit of Energy Use**

**Description.** GDP per unit of energy uses is gauged by GDP per kilogram of oil equivalent of energy use in 2000 US dollars in purchasing power parity (PPP) rates. Energy includes coal, crude oil, petroleum products, gas, nuclear, hydro, geothermal, solar, wind, and electricity (International Energy Agency, 2007). Energy use refers to the use of primary energy before transformation to other end-use fuels, which is equal to indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft that are engaged in international transport (The World Bank, 2007). Purchasing power parity (PPP) are the currency conversion rates that both convert to a common currency and equalize the purchasing power of different currencies (The World Bank, 2007).

**Reliability.** GDP per unit energy consumption has been collected and calculated by the International Energy Agency, established in 1974 as a framework of the OECD (International Energy Agency, 2007). The GDP per unit energy consumption is
evaluated by The World Bank according to the Fundamental Principles of Official Statistics and the Principles Governing International Statistical Activities of the United Nations Statistical Division (The World Bank, 2007). There is always a possibility that outliers or erroneous data might occur in the data recording process, even though they were collected by numerous international organizations. To ensure the reliability of the data, the data of GDP per unit of energy was eliminated from this study if it displayed a significant shift, defined here as 10 times or more, between the previous or following year within the timeframe of 1990 to 2006 (Iwami, 2005).

**Validity.** The GDP per unit energy consumption assessed by The World Bank has established convergent and discriminant validity according to the Fundamental Principles of Official Statistics and the Principles Governing International Statistical Activities of the United Nations Statistical Division (The World Bank, 2007). However, as a macroeconomic indicator, GDP per unit of energy use raises two definitional issues. First, GDP per unit of energy use excludes non-monetized transactions by definition. As a result, it might over- or under-estimate the GDP per unit of energy use of an economy. Secondly, energy consumption implies equal pollution dissemination among energies, despite the fact that some forms of energy, such as wind, are cleaner than others, such as brown coal. Nevertheless, GDP per unit of energy use is still significant in describing and explaining economic activities up to today, even with its deficiencies (Schiller, 2005).

**Secondary industry to GDP**

**Description.** A secondary industrial value to GDP comprises value added in construction, electricity, gas, manufacturing, mining, and water, by definition. Value
added is the net output of a sector after summing up all outputs, and then subtracting intermediated input in order to avoid double counting (The World Bank, 2007).

**Reliability.** The collection, calculation, and checking of secondary industry to GDP by The World Bank are determined by a series of international standards which comprise the International Standard Industrial Classification division 10-45, revision 3 and the Fundamental Principles of Official Statistics and the Principles Governing International Statistical Activities of the United Nations Statistical Division (The World Bank, 2007). Even the reliability of secondary industry to GDP has been checked by The World Bank Group, since it is possible that outlier or error data might occur due to the data recording and coding process. In order to ensure the reliability of the data, this study will exclude data that significantly changes 10 times or more during any two year span within the 1990 to 2006 timeframe.

**Validity.** The secondary industry to GDP assessed by The World Bank has established convergent and discriminant validity corresponding to codes of International Standard Industrial Classification division 10-45, revision 3 and the Fundamental Principles of Official Statistics and the Principles Governing International Statistical Activities of the United Nations Statistical Division (The World Bank, 2007). Therefore, secondary industrial value added to GDP has been examined for its validity by The World Bank group. The secondary industry to GDP has the same validity problems as the GDP per capita. The secondary industry to GDP excludes non-monetized and illegal transactions by definition. As a result, it is quiet possible to over- or under-estimate the contribution of secondary industry to GDP if under the table transactions or black markets are common in an economy. Even with these deficiencies, the secondary
industry to GDP is available as an indicator in describing the economic structure of a country.

**Foreign Direct Investment**

*Description.* Foreign direct investment is long-term investment by foreign investors in a company residing in a country (the host country) other than that in which the foreign investors reside (the source country) (Carter & Turnock, 2005; Froot, 1994; Moosa, 2002). According to The World Bank (2007), foreign direct investors acquire a permanent management interest of at least 10 percent in voting stock in the invested enterprise. The net foreign direct investment on GDP is the sum of inflow of capital to the country divided by its GDP (The World Bank, 2007). Capital includes equity capital, reinvestment of earnings, and other long-term and short-term capital which are shown in the Balance of Payments of an economy (The World Bank, 2007).

*Reliability.* The main sources of net inflows of foreign direct investment of GDP in CEE countries are International Trade Statistics, the international Transaction Report System, and Enterprise Surveys under an agreement of the Marrakech Action Plan for Statistics (The World Bank, 2007). However, data may be unreliable because of improper collection or unavailable sources (The World Bank, 2007). In addition, even in integrity data, data can be compromised if transactions are incompletely reported (The World Bank, 2007). Therefore, data with significant changes 10 times or more in any two year span from 1990 to 2006 will be excluded to ensure the reliability of this study.

*Validity.* As with GDP per capita, the foreign direct investment to GDP excludes non-monetized and illegal transactions by definition. As a result, it is similarly possible to over- or under-estimate the contribution of foreign direct investment to GDP if under
table transactions or black markets are common in an economy. Even with these disadvantages, the foreign direct investment to GDP is still available as an indicator in describing the openness of an economy related with environment deterioration.

**International Trade**

**Description.** Trade of a country is measured by the sum of exports and imports of goods and services (Hockman & Djankov, 1996; The World Bank, 2007). Exports include goods and services that are produced domestically but sold abroad. Imports are goods and services that are produced abroad but sold domestically. International trade, therefore, could be greater than, equal to, or less than GDP.

**Reliability.** The data sources for shares of trade on GDP in The World Bank database are International Trade Statistics, the International Transaction Reporting System, and Enterprise Surveys under a guideline of the Marrakech Action Plan for Statistics (The World Bank, 2007). However, data may be untrustworthy due to improper collection or source incompatibility (The World Bank, 2007). Additionally, even with integrity data, the data can be compromised if transactions are incompletely reported (The World Bank, 2007). Therefore, data with significant changes, defined here as 10 times or more, between the previous and the following year from 1990 to 2006 was excluded to ensure the reliability of this study.

**Validity.** Like previous variables that were related to GDP, the data of international trade to GDP has the same validity problems as the data of the GDP per capita. International trade to GDP excluded non-monetized and illegal transactions by definition. Therefore, it might over-and under-estimated the share of international trade to GDP in an economy. Like foreign direct investment, even though it has some
disadvantages, the international trade is still useful in describing the openness of an
economy's relationship to environment deterioration (Ansuategi, 2003; Copeland &
Taylor, 2004).

Emissions Indicators

Environmental topics cover a wide range of issues, from atmosphere and terrestrial
ecosystems to early warning (Turner, Clark, Kates, Richards, Mathews, & Mayer, 1991;
York et al., 2003). This study focused on the atmosphere, because climate change caused
by anthropogenic greenhouse gases has emerged as one of the most important
environmental issues facing the global environmental warning (Böhringer, 2003; Codur,
2004). According to the Kyoto Protocol, an international treaty on climate change, there
are six greenhouse gases—carbon dioxide, sulphur dioxide, nitrogen oxide, methane,
hydrofluorocarbons, and perfluorocarbons—that significantly affect the environment.
These six greenhouse gases must be reduced. This study examined two greenhouse gases,
carbon dioxide and sulphur dioxide, covering a period from 1990 to 2006 or used the
most recent data available. This study did not include nitrogen oxide, methane,
hydrofluorocarbons, and perfluorocarbons because of insufficient cross-country and over
time data available.

Carbon Dioxide (CO₂)

Description. Carbon dioxide emissions stem primarily from the burning of fossil
fuels and the manufacture of cement. Carbon dioxide is a by-product generated during
consumption of solid, liquid, and gas fuels and gas flaring (The World Bank, 2007).
Man-made sources of CO₂ come principally from the burning of various fossil fuels for
power generation and transport use (Codur, 2004). Since the start of industrial revolution,
the atmospheric CO₂ concentration has increased by approximately 40%, most of it released since 1945 (Codur, 2004). The widely held belief among the scientific community is that this increase in CO₂ causes global climate change, which in turn causes deterioration, deforestation, extinction of flora and fauna, and ozone depletion (Turner et al., 1991; York et al., 2003).

The data on carbon dioxide emissions published by The World Bank come from the Carbon Dioxide Information Analysis Center, which is the primary global-change data and information analysis center of the United States Department of Energy (The World Bank, 2007). In this study, the unit of emission of CO₂ was measured by metric tons per capita.

**Reliability.** The Carbon Dioxide Information Analysis Center receives data from a variety of sources, including individual scientists, projects, institutions, local and national data centers, and others. In order to ensure measurement quality of carbon dioxide, data must be gathered from (1) statements or recommendations of international scientific organizations; (2) data management plans of major international projects; or (3) voluntary data contributions made by agreement with the Carbon Dioxide Information Analysis Center. Once data are received, the Center is responsible for its assimilation, compilation, inventory preparation, archiving, retrieval, and dissemination. In other words, the data are collected and tested through a series of critical processes of the Carbon Dioxide Information Analysis Center. However, as always, recording errors may have occurred in processes such as editing and data transition. These errors affect the accuracy and reliability of the data. Any data with significant changes, defined here as 10 times or
more, between the previous and the following year for the timeframe of 1990 to 2006 were excluded to assure the reliability of data.

Validity. CO₂ is one of the emissions that exist in atmosphere that affects the environment significantly. Other environmental indicators, such as organic water pollutant emissions, particulate matter concentrations, and changes of forest area, are indicators related with emissions. However, there is not enough over time and cross country data available related with those indices, therefore, their reliability and validity has not been fully established. The per capita emission of CO₂ is still a useful index in measuring environmental deterioration (Archibald et al., 2004)

Sulphur Dioxide (SO₂)

Description. Man-made sulphur dioxide is produced by various industrial processes, particularly by the burning of poor-quality coal and petroleum. The emission of sulphur dioxide results in sulphuric acid and acid rain, which can change the global climate, increase the acidity of the soil, and affect the chemical balance of lakes and streams (Böhringer, 2003; Codur, 2004). In other words, emissions of SO₂ are likely to change ecological systems through loss of biodiversity and extinction of flora and fauna (Böhringer, 2003; Codur, 2004). Data referring to sulphur dioxide in CEE and SEA came from Stem (2005). The unit of SO₂ in this investigation was kilogram per capita.

Reliability. Stern’s (2005) per capita emission of SO₂ data is taken from a variety of sources, including individual scientists, projects, international institutions, local and national data centers, and others. In order to ensure measurement quality of sulphur dioxide, Stern (2005) used a multi-output production function that produces pollution emissions, the EKC method, and the growth rate method to ensure the reliability and
validity of the data. However, in order to ensure the reliability of the sulphur dioxide data, any data with significant changes, defined here as 10 times or more, between the previous and the following year for the timeframe of 1990 to 2006 was excluded to assure the reliability of data.

**Validity.** Emission of SO$_2$ is one of the undesirable atmospheric concentrations with regard to environmental quality. Like CO$_2$, emissions of nitrogen oxide, organic water pollutant emissions, and methane are other forms of pollution that are related to environmental deterioration. Since there is not enough over-time and cross country data available in those indices, their reliability and validity has not been fully established. The per capita emission of sulphur is still one of the representative indices with regard to environmental deterioration (Archibald et al., 2004).

**Country Categories**

**Central and Eastern European (CEE) Countries**

The eight CEE countries, including the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, the Slovak Republic, and Slovenia, were selected for this study because (1) they were the most advanced countries of the former communist societies (Cross & Suhrcke, 2000); (2) these eight CEE countries have affiliated with the EU simultaneously in 2004 (Archibald et al., 2004); (3) though it has been more than 16 years since CEE countries were in transition to a market economy, significant differences, such as higher share of employment in industry and higher energy use than expected on the basis of their income per capita, remain in CEE countries (Gros & Suhrcke, 2000); (4) there was no literature found that compared the relationship of economic growth and environmental deterioration between transitional and non-transitional economies with
similar income levels; (5) CEE pushed through comprehensive transformations of their economic, political, and institutional systems so as to be more consistent with their Western counterparts. This transformation was unique in the history of human development (Archibald, Banu, & Gochniarz, 2004; Kornai, 2006). All these characteristics have made the CEE a unique economy that is different from most existing Western economies. Therefore, it was worthwhile to determine whether the CEE would duplicate the trajectory of the economic and environmental development processes of the most advanced Western countries.

**South and East Asian (SEA) Countries**

The six SEA countries—Indonesia, the Korean Republic, Malaysia, the Philippines, Singapore, and Thailand—were identified in order to compare the relationship between their economic development and environmental deterioration with CEE’s. These SEA countries were selected for two reasons. First, SEA countries are perceived as having similar economic expansion trends as CEE countries (Gross & Suhrcke, 2000). Both CEE and SEA, for example, are similar in that they stimulate economic growth by enacting policies that attract foreign direct investment (Gros & Suhrcke, 2000). Besides, CEE and SEA countries have relied heavily on the industrial sector during their developmental process (Gros & Suhrcke, 2000). Secondly, all CEE and SEA countries were classified as either high-income or middle-income countries, but contained differences in their economic system—CEE’s are transitional economies and SEA’s are market economies (Gros & Suhrcke, 2000).
Procedures: Ethical Considerations and Data Collection Methods

1. An application was submitted to the Lynn University Institutional Review Board (IRB) for the investigator to conduct this research.

2. Permission was obtained via mail to use sulphur data in this study (see Appendix A).

3. The online data retrieval and recording commenced start date (January 10th, 2007) was the date after this study was approved by the IRB and the completion date (February 10th, 2007) was one month after the date for starting data collection.

4. An IRB Form 5, Application for Procedural Revisions of or Changes in Research Protocol and/or Informed Consent Form I of a Previously Approved Project, was submitted to the IRB of Lynn University for changing source of sulphur data.

5. Data were analyzed using SPSS for Windows version 14.0.

Methods of Data Analysis

This investigation utilized the statistical software of SPSS 14.0 to analyze the data. Descriptive statistics, multiple regression, and independent t-tests were statistics that applied in this study.

Descriptive Statistics: Research Questions

To answer research question 1, a time series analysis of frequency distributions, measures of central tendency, and variability was conducted to describe the macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and per capita emissions (CO₂ and SO₂) of each CEE and SEA countries and all the CEE country as one group and all the SEA country as another group.
For research question 2, a time series analysis of the percentage of change of macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and percentage change of per capita emissions (CO₂ and SO₂) was conducted for CEE and SEA countries, individually and as two groups—CEE group and SEA group.

To answer research question 3, a time series analysis of differences in frequency distributions, measures of central tendency, and variability was conducted to describe the macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and per capita emissions (CO₂ and SO₂) of all CEE and SEA countries as a group.

**Inferential Statistics: Hypotheses Testing**

The linear regression analysis with panel data of CEE and SEA countries was applied in testing the hypotheses 1 to 5 and their sub-hypotheses of this study.

**Multiple Regression Analysis**

To test hypothesis 1, that there is a significant curvilinear explanatory relationship among macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and per capita emissions (CO₂ and SO₂)—a linear regression analysis with panel data for the eight CEE countries with structural equations (1) and (2) was applied as follows:

\[
C_{it} = \beta_0 + \beta_1 Y + \beta_2 Y_i^2 + \beta_3 EC_{it} + \beta_4 SI_{it} + \beta_5 FDI_{it} + \beta_6 IT_{it} + \varepsilon_{it} \quad \cdots \cdots \quad (1)
\]

\[
S_{it} = \rho_0 + \rho_1 Y + \rho_2 Y_i^2 + \rho_3 EC_{it} + \rho_4 SI_{it} + \rho_5 FDI_{it} + \rho_6 IT_{it} + \mu_{it} \quad \cdots \cdots \quad (2)
\]

Subscript \(i\) represents the CEE countries, and \(t\) is the year. Explanatory variables included \(Y, Y^2, EC, SI, FDI,\) and \(IT\). \(Y\) represents GDP per capita in constant 2000 US
dollars. $Y^2$ is quadratic $Y$, which was created here for the purposes of EKC hypothesis. This addressed a curvilinear relationship between environmental deterioration and income. $EC, SI, FDI$ and $IT$ represent exogenous variables that comprise GDP per unit of energy use, secondary industrial to GEP, foreign direct investment, and international trade respectively. $C$ and $S$ are emission indices of per capita CO$_2$ and per capita SO$_2$ respectively. The intercepts $\beta_0$ and $\rho_0$ denote the country-specific effects. The $\beta_1$ to $\beta_6$ and $\rho_1$ to $\rho_6$ denote the explanatory variables effects on each emission. The $\varepsilon$ and $\mu$ are the error terms of per capita CO$_2$ and SO$_2$ emissions, respectively. These error terms represented the amount by which an observation differed from its expected value for each regression.

To support research hypothesis 1 of a significant curvilinear relationship among macroeconomic indicators and emissions, three conditions must have been met: (1) the $F$ statistic must be significant ($p < .05$), which is a test of the overall regression model; (2) the sign of $Y$ term and the sign of $Y^2$ in the regression models (1 and 2) must be positive and negative respectively, and (3) the $Y$ and $Y^2$ must have significant $t$-statistics ($p < .05$)

To test hypothesis 2, a linear regression analysis with panel data and all macroeconomic and per capita emissions indicators data in SEA countries was utilized. The regression models of the hypothesis are represented as follows:

$$C_{it} = \alpha_0 + \alpha_1 Y + \alpha_2 Y^2 + \alpha_3 EC_{it} + \alpha_4 SI_{it} + \alpha_5 FDI_{it} + \alpha_6 IT_{it} + \xi_{it} \quad ....................(3)$$

$$S_{it} = \sigma_0 + \sigma_1 Y + \sigma_2 Y^2 + \sigma_3 EC_{it} + \sigma_4 SI_{it} + \sigma_5 FDI_{it} + \sigma_6 IT_{it} + \tau_{it} \quad ....................(4)$$

All the symbols in equation (3) and (4) are the same as they are in equation (1) and (2). $\alpha_0$ and $\sigma_0$ in equation (3) and (4) are intercept terms which donate country-specific effects. $\alpha_i$ to $\alpha_6$ and $\sigma_i$ to $\sigma_6$ donate the explanatory variables' effects on each emission.
\( \zeta \) and \( \tau \) are the error terms, which denote the amount by which an observation differs from its expected values of per capita CO\(_2\) and per capita SO\(_2\), respectively. Variable \( Y \) is GDP per capita in 2000 constant US dollars. \( Y^2 \) is quadratic \( Y \), which is added here for the purposes of testing the EKC hypothesis. The population of equations (3) and (4) refers to SEA countries.

To support research hypothesis 2 of a significant curvilinear relationship among macroeconomic indicators and emissions, three conditions must have been met: (1) the \( F \) statistic must be significant (\( p \leq .05 \)), which is a test of the overall regression model; (2) the sign of \( Y \) term and the sign of \( Y^2 \) in the regression models (3 and 4) must be positive and negative respectively, and (3) the \( Y \) and \( Y^2 \) must have significant \( t \)-statistics (\( p \leq .05 \)).

A panel data of CEE countries was adopted to test hypothesis 3. There is a significant curvilinear explanatory relationship among the percent change in macroeconomic indicators and the percentage change in emissions in CEE countries. The reduced forms of linear regression models are specified as follows:

\[
\ln C_{it} = \delta_0 + \delta_1 \ln Y + \delta_2 (\ln Y)^2 + \delta_3 \ln EC_{it} + \delta_4 \ln SI_{it} + \delta_5 \ln FDI_{it} + \delta_6 \ln IT_{it} + \varphi_{it} \ldots (5)
\]
\[
\ln S_{it} = \mu_0 + \mu_1 \ln Y + \mu_2 (\ln Y)^2 + \mu_3 \ln EC_{it} + \mu_4 \ln SI_{it} + \mu_5 \ln FDI_{it} + \mu_6 \ln IT_{it} + \pi_{it} \ldots (6)
\]

All the symbols in equations (5) and (6) are the same as they are in equations (1) and (2). Variables are expressed in natural logarithm (ln) in order to see the percentage change (or elasticity) between outcome variables (per capita CO\(_2\) and per capita SO\(_2\)) and explanatory variables (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade). The \( \delta_0 \) and \( \mu_0 \) in equations (5) and (6) respectively are intercept terms that denote country-specific effects. The \( \delta_1 \) to \( \delta_6 \) and \( \mu_1 \) to \( \mu_6 \) denote the explanatory variables' effects on each emission. The \( \varphi \) and \( \pi \) are

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the error terms, which denote the amount by which an observation differs from its expected values of percentage changes in per capita CO₂ and percentage changes in per capita SO₂, respectively. Variable Y is GDP per capita in 2000 constant US dollars. \((lnY)^2\) is quadratic \(lnY\), which is added here for the purposes of testing the EKC hypothesis.

Three conditions must be met to support hypothesis 3: (1) the \(F\) statistic must be significant \((p \leq .05)\), which is a test of the overall regression model; (2) the sign of \(lnY\) term and the sign of \((lnY)^2\) in the regression models (5 and 6) need to be positive and negative respectively, and (3) the \(lnY\) and the \((lnY)^2\) must have significant \(t\)-statistics \((p \leq .05)\).

A linear regression analysis with panel data of SEA was applied in testing hypothesis 4. The regression models are:

\[
lnC_i = \omega_0 + \omega_1 \ln Y_{it} + \omega_2 (lnY_{it})^2 + \omega_3 lnEC_{it} + \omega_4 lnSI_{it} + \omega_5 lnFDI_{it} + \omega_6 lnIT_{it} + \kappa_i \ldots (7)
\]

\[
lnS_i = \eta_0 + \eta_1 \ln Y + \eta_2 (lnY_{it})^2 + \eta_3 ln EC_{it} + \eta_4 lnSI_{it} + \eta_5 lnFDI_{it} + \eta_6 lnIT_{it} + \psi_i \ldots (8)
\]

All the symbols in equations (7) and (8) are the same as they are in equations (1) and (2). Variables are expressed in logarithm \((ln)\) in order to see the percentage change (or elasticity) among outcome variables (per capita CO₂ and per capita SO₂) and explanatory variables (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) in SEA countries. The \(\omega_0\) and \(\eta_0\) in equations (7) and (8) are intercept terms that denote country-specific effects. The \(\omega_1\) to \(\omega_6\) and \(\eta_1\) to \(\eta_6\) donate the explanatory variables’ effects on each emission. The \(\kappa\) and \(\psi\) are the error terms, which denote the amount by which an observation differs from its expected values of CO₂ and SO₂ respectively. Variable \(Y\) is GDP per capita in 2000.
constant US dollars. \((\ln Y)^2\) is quadratic \(\ln Y\), which was added here for the purposes of testing the EKC hypothesis.

To support research hypothesis 4 of a significant curvilinear relationship between percentage changes in macroeconomic indicators, three conditions must have been met: (1) the \(F\) statistic must be significant \((p \leq .05)\), which is a test of the overall regression model; (2) the sign of \(\ln Y\) term and the sign of \((\ln Y)^2\) in the regression models (7 and 8) must be positive and negative respectively, and (3) the \(\ln Y\) and \((\ln Y)^2\) must have significant \(t\)-statistics \((p \leq .05)\).

A curvilinear regression model with panel data of CEE and SEA countries was utilized in testing hypothesis 5, the percentage change of macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and country category (CEE and SEA) are significantly explanatory variables of percentage change of per capita emissions (CO\(_2\) and SO\(_2\)).

\[
\ln C_{it} = \theta_0 + \theta_1 \ln Y_{it} + \theta_2 (\ln Y_{it})^2 + \theta_3 \ln EC_{it} + \theta_4 \ln SI_{it} + \theta_5 \ln FDI_{it} + \theta_6 \ln IT_{it} + \theta_7 CEEC_{it} + u_{it} \tag{9}
\]

\[
\ln S_{it} = \chi_0 + \chi_1 \ln Y_{it} + \chi_2 (\ln Y_{it})^2 + \chi_3 \ln EC_{it} + \chi_4 \ln SI_{it} + \chi_5 \ln FDI_{it} + \chi_6 \ln IT_{it} + \chi_7 CEEC_{it} + \varsigma_{it} \tag{10}
\]

The population for regression equation for (9) and (10) included all macroeconomic and emissions data of eight CEE and all six SEA countries. All the symbols are the same as they are in equation (7) and (8) except for one new variable, CEEC. CEEC denotes the eight CEE countries, used here to test if to be a CEE country was a significant explanatory variable of emissions (CO\(_2\) and SO\(_2\)). Variables are
expressed in logarithm (ln) in order to see the percentage change (or elasticity) between outcome (per capita CO\textsubscript{2} and per capita SO\textsubscript{2}) and macroeconomic indicators (GDP per capita, GDP per unit of energy consumption, secondary industry to GDP, foreign direct investment, and international trade). CEEC, an attribute variable within the country category, was designed as a dummy variable which represented the CEE countries if CEEC is equal to 1, otherwise it represents SEA countries whenever CEEC equal to 0. The notations of $\theta_0$ and $\chi_0$ are intercept terms that donate country specific effects on emissions of CO\textsubscript{2} and SO\textsubscript{2} respectively. The $\theta_1$ to $\theta_6$ and $\chi_1$ to $\chi_6$ donate macroeconomic variables affects on each emission. The $\theta_7$ and $\chi_7$ denote economic background effects on emissions. The $\iota$ and $\zeta$ are the error terms, which denote the amount by which an observation differs from its expected values of CO\textsubscript{2} and SO\textsubscript{2} in all CEE and SEA countries.

To support hypothesis 5, two conditions must be met: (1) the $F$ statistic must be significant ($p \leq .05$), which is a test of the overall regression model; (2) country category, CEEC, must each have a significant $t$-statistic ($p \leq .05$).

**Independent t-Tests**

Independent $t$-tests were used to test hypothesis 6 that there are significantly fewer per capita emissions (CO\textsubscript{2} and SO\textsubscript{2}) in CEE, transitional countries compared with SEA, non-transitional countries, based on data from 1990 to 2006, or the most recent data available. The data of per capita emissions (CO\textsubscript{2} and SO\textsubscript{2}) in panel data of CEE and SEA countries was used. Two steps were taken to test hypothesis 6. For the first, the $F$ statistic, which is a test for equality of variances ($p \leq .05$) was conducted. If the
variances were unequal, the adjusted $t$-values were used to examine differences with significance at the $p \leq .05$ levels to support hypothesis 6.

**Evaluation of Research Methodology**

The previous sections of this chapter have one goal in general—enhancing the internal and external validity of this research. Internal validity refers to the ability to draw confident causal outcomes from research (Babbie, 2004; Johnson, 2001; Schram, 2005). Strong internal validity is not only connected with reliable and valid measures of variables, but also a forceful justification that causally connects independent variables to dependent variables (Babbie, 2004; Scharm, 2005). External validity addresses the ability to generalize findings from a study to other populations and other settings (Babbie, 2004; Scharm, 2005). The internal and external validity of this study is addressed by reviewing the strengths and weakness in research design, population and sampling, measurement, and the methods of data analysis.

**Internal Validity**

**Strengths**

1. Quantitative research design: this quantitative, non-experimental correlational (explanatory), causal-comparative analysis makes observations about dependent and independent variables, which are more direct and easier to identify from research (Babbie, 2004; Johnson, 2001). Quantitative analysis permits potentialities of statistical analyses, ranging from simple descriptive statistics to complex inferential statistics (Babbie, 2004; Johnson, 2001).
2. Unbiased sampling: since an entire target population, excluding potential outliers, is involved in this investigation, selection bias is avoided.

3. Measurement: most secondary data are works of celebrated institutions or have been cited by literature, which provides data covering a wide range of possibilities available for finding and checking the answers to the research’s questions (Babbie, 2004). These secondary data were obtained and recorded globally with standardized processes over years, providing consistent data for time series and cross countries analysis.

4. Panel data: since macroeconomic and emissions indicators were collected by time order, time series analysis can explain the fact that over time data may have internal auto-correlation or other such tendencies that should be accounted for (Babbie, 2004). That is, a time series approach allows researchers to investigate patterns of explanatory variables across a large number of countries and over years. It has the advantage of generalizability, yielding insights that are more generally applicable across a range of different area contexts (Perkins & Neumayer, 2005).

5. Curvilinear regression analysis: the regression equation procedure involved setting parameters by using standard techniques and finds the linear relationship that best fits the data (Harrell, 2001). Therefore, time series data with regression analysis has brought justification that causally connects independent variables to dependent variables.

6. Sufficient sample size in CEE region: there were more than 100 observations of each variable in CEE region. Therefore, the observations were more than
minimum sample size required, 90 observations, for regression analysis in CEE region (Babbie, 2004).

**Weakness**

1. Quantitative research design: quantified analysis may easily over-simplify data by aggregation, comparison, and summarization data to meet data analysis standards, which results in a direct misreading of real phenomena (Babbie, 2004; Cavana, Delahaye, & Sekaran, 2001). Quantification reflects an outcome with a probability of error ($p \leq .05$ normally in this study) rather than signifying a true fact (Babbie, 2004; Sekaran, 2003). Quantification, moreover, generalizes the phenomena of the real world by ignoring individual specific circumstances (Babbie, 2004; Sekaran, 2003). For example, The World Bank data on CO$_2$ is published according to a yearly average by country, which ignores seasonal and regional variations.

2. Non-experimental studies: one of the disadvantages of utilizing non-experimental studies is the presence of unrecognized confounding variables. In a science study, when testing the effect of a possible factor or influence on a target parameter, investigators must manipulate independent variables of influence. However, it is difficult to manipulate all known or unknown variables in social science subjects, including issues surrounding economic growth and environmental deterioration.

3. Limited variables: this research uses secondary data from The World Bank and Stern (2005); therefore, analysis is limited to what already exists. This existing data may not correspond exactly with research questions to be
answered and research hypotheses to be tested (Babbie, 2004; Johnson, 2001). Emissions and GDP data, for example, are sensitive to seasonal effects rather than yearly average effects. However, cross-country seasonal data are unavailable in many eminent institutions.

4. Measurement: all the variables in this study are presented by yearly aggregation, which is less valuable than seasonal or monthly data in explaining the diversity of individual variable changes and characteristics.

5. Confounding variables: other variables, such as urbanization, pollution tax or subsidies, fiscal policies for environmental improvement spending, income inequality, environmental regulations, and other factors may have influenced emissions other than the factors that are included in this study.

6. Missing data due to variability: all dependent and independent variables will be excluded if there is a significant change of 10 times or more between the previous and following years. This might affect the accuracy (reliability) of the variables.

7. Insufficient sample size in SEA region: there were only 84 observations of CO₂ emissions and 66 observations of SO₂ emissions data in SEA. Both observations were less than minimum sample size required, 90 observations, for regression analysis. Insufficient in sample size might result in estimates of errors (Babbie, 2004).
External Validity

Strengths

1. Homogeneity in the CEE: CEE countries are homogeneous in both transactional processes and time of transformation, which means that fewer external variables are available (Babbie, 2004). They share the fact that the economic system of the CEE comes from command socialism and is moving toward market capitalism. Additionally, the transformation took place, by and large, at the end of the 1980s and the beginning of the 1990s.

2. Homogeneity in the SEA: SEA countries are homogeneous in economic development process, which depends heavily on industrialism and puts focus on attracting foreign direct investment as a primary stage of their development. In addition, all the SEA countries are either high-income or middle-income countries, according to The World Bank data (The World Bank, 2007).

3. Population and sampling: the entire target population of the CEE and the SEA countries constitutes the samples. As a result, there is no sampling bias question, which is the issue that carries most external validity problems (Babbie, 2004).

Weakness

1. Country characteristics: this study is limited to eight transitional CEE and six non-transitional SEA countries. Results, therefore, cannot be generalized to other countries.
2. Emissions: this study focuses on emissions of CO₂ and SO₂ only. Results cannot be generalized with reference to other gases, such as methane, hydrofluorocarbons, and perfluorocarbons.

3. Atmosphere: whereas this investigation is focused on atmosphere, consequences cannot apply to other environmental deterioration issues, such as loss of biodiversity, desertification, deforestation, and extinction of flora and fauna.

**Summary of Chapter III**

The main purposes of Chapter III were to present the investigator's epistemological views and fundamental approaches underpinning this research. This chapter identifies the research methodology in this study regarding environmental deterioration and economic growth in CEE and SEA countries. The contexts of Chapter III cross a range of methodologies from theoretical framework, research questions, research hypotheses, research design, population, sample plan, instrumentation, ethical considerations and data collection methods and measurement, to an overall evaluation of the methodology. A quantitative, non-experimental, correlational (explanatory), causal-comparative and panel data was applied in this study. The next chapter, Chapter IV, presents the results based on the research methods developed in Chapter III.
CHAPTER IV

RESULTS

This chapter analyzes and presents the results on the relationship between economic growth and environmental deterioration, the EKC hypothesis, and economic backgrounds in explaining emissions in CEE and SEA countries. The data were analyzed statistically by the SPSS 14.0 program, which included frequency distributions, means, and variability, multiple regression analyses, and independent $t$-tests, to answer research questions and to test hypotheses.

Final Data Producing

Since neither CEE nor SEA has all available data from 1990 to 2006, the most recent data available is utilized according to the indicators. A summary of number of observations per variable per region is given in Table 4-1.
Table 4-1

Summary of Number of Observations

<table>
<thead>
<tr>
<th>Macroeconomic indicators</th>
<th>Regions</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP per capita (constant 2000 US dollars)</td>
<td>CEE 128</td>
</tr>
<tr>
<td>GDP per unit of energy use</td>
<td>CEE 109</td>
</tr>
<tr>
<td>(constant 2000 PPP dollars per kg of oil</td>
<td></td>
</tr>
<tr>
<td>equivalent)</td>
<td></td>
</tr>
<tr>
<td>Secondary industry to GDP (%)</td>
<td>CEE 126</td>
</tr>
<tr>
<td>Foreign direct investment (%)</td>
<td>CEE 114</td>
</tr>
<tr>
<td>International trade (%)</td>
<td>CEE 125</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Emissions indicators</th>
<th>Regions</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂ (per capita tons)</td>
<td>CEE 112</td>
</tr>
<tr>
<td>SO₂ (per capita kgs)</td>
<td>CEE 100</td>
</tr>
</tbody>
</table>


Findings of Research Questions

Research Questions 1

Q1: What are the macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and per capita emissions (CO₂ and SO₂) of CEE and SEA countries from 1990 to 2006 or the most recent data available?

GDP per Capita

CEE countries. The trend of GDP per capita in CEE countries shows a U shape curve, first demonstrating a decrease and then an increase, from 1990 to 2005, which is the most recent available data published by The World Bank (2007). The income decreased by more than 12 percent at the beginning two years of transition, from 3,800
US dollars (in constant 2000 US dollars; this same unit is used in all the following analysis unless otherwise noted) to 3,300 US dollars. In 1996, seven years after transition, the income of CEE returned to its pre-transition level of roughly 3,800 US dollars. Income increased significantly by around 44 percent from 1996 to 2005. The average GDP per capita in CEE countries reached around 5,600 US dollars in 2005. The highest and lowest GDP per capita countries in this area were Slovenia, averaging around US$8,900, and Latvia, average around US$3,200, for the research timeframe.

**SEA countries.** The SEA noticed significant gains in GDP per capita, achieving an increase of over 72 percent from 1990 to 2005. Despite a one-year decline and stagnation at around US$2,250 GDP per capita in 1998, one year after Asian Financial Crises, SEA has experienced sustained annual increases in income since 1990. In 2005, these SEA countries, on average, reached a GDP per capita of over US$2,900. Singapore, at US$20,000, and Indonesia, at US$800, were the highest- and lowest-income countries per capita in this region.

Even though the average income of CEE countries was higher than average income of SEA countries from 1990 to 2005, all the countries in these two groups are classified as either high-income (Korean Republic, Singapore, and Slovenia) or middle-income (the remaining 11) countries (The World Bank, 2007). Furthermore, the population and per capita GDP in CEE and SEA are different. The CEE countries are more similar in terms of per capita income the variation is between US$3,200 and US$8,900. The per capita GDP among SEA countries varies substantially from around US$800 in Indonesia to US$20,000 in Singapore. Likewise, the population of CEE countries is more similar, from 1.3 million in Estonia to 38.5 million in Poland. However, the population of SEA
countries is wide range from 4.5 million in Singapore to 234.7 million in Indonesia. Therefore, the average per capita GDP of SEA is lower than CEE’s (The World Bank, 2007).

The growth trends of GDP per capita in CEE and SEA countries are presented in Figure 4-1. Figure 4-2 presents the average GDP per capita of each country from 1990 to 2005, which is the most recent data available. Table 4-2 presents a summary of GDP per capita of each country and each region, which appears at the end of this section.

Figure 4-1. Average GDP per capita in CEE and SEA countries from 1990 to 2005.

Figure 4-2. Average GDP per capita of each country from 1990 to 2005.


GDP per Unit of Energy Use

CEE countries. The average GDP per unit of energy use in CEE countries has improved remarkably since the transformation to market economy, from 3.3 constant 2000 purchasing power parity dollar per kg of oil equivalent (same unit as follows if there is no specific noticed), in 1990, to over 4.5 in 2004, which is the most recent data available. GDP per unit of energy use, or the total GDP divided by the total energy used, reflects the energy efficiency of an economy (The World Bank, 2007). Most countries in this area consumed energy more efficiently during the research timeframe; the exceptions were the Czech Republic and the Slovak Republic. The GDP per unit of energy use in Czech Republic and the Slovak Republic stayed around 3.5 and 2.8, respectively, from 1990 to 2004. Slovenia, at 4.84, and Estonia, at 2.46, represent the most efficient and the
most inefficient countries in terms of average GDP per unit of energy consumption in this region. Kahn (2002) and Kornai (2006) once characterized the pattern of economic development in this region as being caused by growth of production factors; this is in contrast with the trends of rising productivity that resulted in economic inefficiency under command economic system. However, the trend of GDP per unit energy use between 1990 and 2003 has been improved, as shown in Figure 4-3.

**SEA countries.** GDP per unit of energy use, or energy efficiency, in SEA shows a downward trend for the past decade, from 5.3 in 1991 to 4.9 in 1999 and then back to over 5.1 in 2003. One unexpected finding was that Singapore had the lowest GDP per unit of energy use, 3.5 on average, in this area. The Philippines had the highest GDP per unit of energy use, 7.76 on average, in SEA.

Figures 4-3 shows the trends of GDP per unit of energy use in CEE and SEA from 1990 to 2004. Figure 4-4 shows the average of GDP per unit of energy use in each country. Table 4-2 presents a summary of the average GDP per unit of energy use of each country and region, which appears at the end of this section.
Figure 4-3. Average GDP per unit energy use in CEE and SEA countries from 1990 to 2004.

Secondary Industry to GDP

**CEE countries.** Gros and Suhrcke (2000), Kahn (2002), and Kornai (2006) once characterized industrial development as the foremost priority during the forty years of planned economic system in this region, which resulted in overindustrialization and misindustrialization in the CEE. Even with this heritage of a large industry sector, the average of secondary industry to GDP in CEE country has decreased dramatically in line with the economic reorientation to the market system. The average secondary industry to GDP decreased by one-third during the transition, from over 45 percent in 1990 to around 30 percent in 2005, which is the most recent data available. The Czech Republic, at 41 percent, and Slovenia, at 38 percent, were the two highest countries with secondary industry to GDP in this area. Latvia, at 30 percent, was the lowest country in secondary
industry to GDP from 1990 to 2005.

**SEA countries.** The share of average secondary industry to GDP in SEA countries went up slightly, from 38 percent to 41 percent, during the past 16 years. Over two-fifths of GDP came from the contribution of secondary industry in SEA. Indonesia, at 49 percent, and the Philippines, at 32 percent, were the highest and lowest countries respectively with secondary industry to GDP in this region.

It is clear that both CEE and SEA depended on the industry sector heavily, in line with their economic expansion during the last decades. The contribution of the industry sector to GDP was over one-third percent of total GDP in these two areas for the past 16 years. It is interesting to compare the trends of secondary industry to GDP in these two regions. At the beginning of the 1990s, the average of secondary industry to GDP in CEE, 46 percent, was remarkably higher than that in SEA, 38 percent. However, the trends progressed differently after middle of 1990s, when CEE decreased in the industry sector but SEA stayed at approximately the same level in this sector. As a result, the secondary industry to GDP in CEE decreased to 30 percent, but SEA increased to 41 percent in 2005. That is, SEA depended on the contribution of secondary industry to GDP more heavily than CEE depended on it.

Figure 4-5 shows the trends of secondary industry to GDP in CEE and SEA from 1990 to 2005. Figure 4-6 shows the average shares of secondary industry to GDP of each country. Table 4-2 presents a summary of the average secondary industry to GDP of each country and region in this study, and appears at the end of this section.
Figure 4-5. Average secondary industry to GDP in CEE and SEA countries from 1990 to 2005.

Figure 4-6. Average shares of secondary industry to GDP of each country from 1990 to 2005.


**Foreign Direct Investment**

**CEE countries.** The trend of average foreign direct investment to GDP from 1990 to 2005 showed an increase trend, with the exception of the year 2003. The foreign direct investment to GDP in CEE was under 1 percent at the beginning of transition. It increased to over 6 percent, on average, in the year 2002. Foreign direct investment, however, dropped off dramatically, to under 3 percent in 2003. It then returned to over 6 percent in 2005. Slovenia had the lowest foreign direct investment to GDP in this region, with an average of 1.7 percent 1990 to 2005. Estonia had the highest average foreign direct investment to GDP in this region, averaging over 7 percent from 1990 to 2005.
**SEA countries.** The trend of foreign direct investment to the GDP of SEA countries was quite steady. The foreign direct investment to GDP was around 3.5 to 4 percent from 1990 to 2005, with the exception of the years 2002 and 2003. Between 1990 and 2005, which is the most recent period for which data are available, the highest and lowest countries in foreign direct investment to GDP in SEA were Singapore, with an average of 12 percent, and Indonesia, with an average of 0.5 percent.

Figure 4-7 presents the trends of foreign direct investment in CEE and SEA countries. Figure 4-8 shows the average percentage share of foreign direct investment to GDP in each country. Table 4-2 presents a summary of the average foreign direct investment of each CEE and SEA country and each region from 1990 to 2005, and appears at the end of this section.

![Figure 4-7. Average foreign direct investment in CEE and SEA countries from 1990 to 2005.](image)

Figure 4-8. Average shares of foreign direct investment to GDP of each country from 1990 to 2005.


International Trade

**CEE countries.** The contribution of international trade to GDP was increasing when CEE countries reoriented their economic system to the market economy. The average share of international trade to GDP in CEE, in fact, increased around 40 percent from 1990 to 2005, which is the most recent data available. Estonia had the highest share of international trade to GDP, at 154 percent on average, and Poland was the lowest in international trade to GDP, at 55 percent on average.

**SEA countries.** As in CEE countries, the international trade to GDP in SEA has increased remarkably, from 126 percent in 1990 to 179 percent in 2005, which is the most recent data available. The international trade to GDP increased by roughly 53 percent in this region from 1990 to 2005. Singapore, at 357 percent on average, and
Indonesia, at around 60 percent on average, were the highest and lowest countries respectively in international trade to GDP in this area.

The trends of international trade to GDP in CEE and SEA are presented in figure 4-9. Figure 4-10 shows the average shares of international trade to GDP in each country. Table 4-2 presents a summary of the average international trade of each country and region in this survey, and appears at the end of this section.

![Figure 4-9. Average international trade to GDP in CEE and SEA countries from 1990 to 2005.](image)

*Note. Data for analysis purchased from "World Development Indicator," of The World Bank, 2007.*
Figure 4-10. Average shares of international trade to GDP of each country from 1990 to 2005.


Carbon Dioxide (CO₂)

**CEE countries.** The per capita CO₂ emissions in CEE dropped significantly from 1990 to 2003 in conjunction with economic expansion. The average per capita CO₂ emissions were 9.53 and 7.80 tons in 1990 and 2003, respectively. In other words, the per capita CO₂ emission dropped 1.73 tons in the 1990 to 2003 timeframe in CEE countries. The levels of per capita CO₂ emission can be significantly different among countries. Some countries, such as the Czech Republic and Estonia, averaged over 12 tons per capita per year. Other, such as the Slovak Republic and Slovenia, averaged around 7 tons per capita per year. The others, Latvia and Lithuania, averaged around 4 tons per capita per year. As a result, there was more than a 300% difference between the
highest levels of per capita CO$_2$ emission and the lowest levels of emissions in the CEE countries region from 1992 and 2003, which is the most recent data available.

**SEA countries.** CO$_2$ emissions increased in line with economic expansion in SEA in the past decades. The average was 1.76 per capita tons of CO$_2$ emission in 1990 in this region. However, as of 2003, the most recent data available, the average per capita CO$_2$ emission had increased to 2.94 tons. It increased over 1 ton per capita from 1990 to 2003 in this area. As in CEE countries, the emission of CO$_2$ in SEA can be significantly different among countries. For example, there was a difference of over 1500% between the country with the highest rates of CO$_2$ emission (Singapore, at 14.53 per capita tons on average) and the lowest (the Philippines, averaging 0.92 tons per capita).

The tendencies of CO$_2$ emission in CEE and SEA were opposed between 1990 and 2003. The CO$_2$ emissions decreased in the CEE but increased in the SEA. Even though CO$_2$ emissions have decreased in CEE, they were still remarkably higher than in SEA countries. The average CO$_2$ emission rate was 8.32 tons per capita in CEE and 2.57 tons per capita in SEA in the past decades.

Figure 4-11 presents the tendencies of per capita CO$_2$ emission in these two groups. Figure 4-12 shows the average per capita CO$_2$ emission in each country. Table 4-2 presents a summary of the average per capita CO$_2$ emission in each country and region, and appears at the end of this section.
Figure 4-11. Average per capita CO$_2$ emissions in CEE and SEA countries from 1990 to 2003.

Figure 4-12. Average per capita CO₂ emissions in each country from 1990 to 2003


Sulphur Dioxide (SO₂)

CEE countries. The average emissions of SO₂ in CEE countries have greatly decreased, in line with the economic reorientation to a market economy. The average SO₂ emissions decreased from around 1060 kilograms per capita in 1990 to around 487 kilograms per capita in 2002, which is the most recent data available. SO₂ emissions decreased by over 50 percent within that timeframe. Poland was the country with the highest SO₂ emissions, averaging 1138 kilograms per capita. Latvia was the country with the lowest SO₂ emissions in this region, averaging 25kg per capita.
**SEA countries.** The average emissions of $\text{SO}_2$ in SEA countries increased from 359 kilograms per capita in 1990 to 393 kg per capita in 2000, which is the most recent data available. The highest and lowest rates of per capita $\text{SO}_2$ emission in SEA were, respectively, in Thailand, averaging 566 kilograms per capita, and in Singapore, averaging 100 kg per capita.

Figure 4-13 shows the tendencies of per capita $\text{SO}_2$ emission in CEE and SEA countries from 1990 to 2000 in SEA and 2002 in CEE. Figure 4-14 shows the average per capita $\text{SO}_2$ emission in each country. Table 4-2 presents a summary of the average emissions of $\text{SO}_2$ in each country and region, and appears at the end of this section.

![Figure 4-13. Average per capita $\text{SO}_2$ emissions in CEE and SEA countries from 1990 to 2002 or the most recent data available.](image)

Figure 4-14. Average per capita SO$_2$ emissions in CEE and SEA countries from 1990 to 2002 or the most recent data available.


Summary of Macroeconomic and Emissions Indicators of CEE and SEA Countries

The average income of CEE countries, 4258 in 2000 US dollars, was higher than average income of SEA countries, 2393 in 2000 US dollars, from 1990 to 2005. However, the CEE countries were more similar in terms of per capita income the variation was between US$3200 and US$8900. The per capita GDP among SEA countries varies substantially from around US$800 in Indonesia to US$20000 in Singapore.

The average GDP per unit of energy use in SEA and CEE countries were 4.4 and 3.75 respectively, in constant 2000 purchasing power parity dollar per kg of oil.
equivalent during 1990 and 2004 research timeframe. That was, in general, the SEA countries were more efficiency in energy use than that of in CEE countries during 1990 and 2004 research timeframe. One unexpected finding was that the SEA region had higher secondary industry to GDP than that of in CEE region because CEE was widely regarded as overindustrialization in the former centrally-planned economies. Table 4-2 presents the average macroeconomic and emissions indicators of CEE and SEA countries from 1990 to 2005 or the most recent data available.
Table 4-2
Average Macroeconomic and Emissions Indicators of CEE and SEA Countries from 1990 to 2005 or the Most Recent Data Available

<table>
<thead>
<tr>
<th>Indicators (average of 1990 to 2005 or the most recent data available)</th>
<th>GDP per capita (2000 US$)</th>
<th>GDP per unit of energy use</th>
<th>Secondary industry to GDP (%)</th>
<th>Foreign direct investment (%)</th>
<th>International trade (%)</th>
<th>CO₂ (per capita ton)</th>
<th>SO₂ (per capita kg)</th>
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<td>5,404.21</td>
<td>3.66</td>
<td>41.04</td>
<td>5.52</td>
<td>116.22</td>
<td>12.28</td>
<td>456.52</td>
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<td>Estonia</td>
<td>3,778.33</td>
<td>2.50</td>
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<td>7.33</td>
<td>154.07</td>
<td>13.79</td>
<td>74.20</td>
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<td>Hungary</td>
<td>4,327.75</td>
<td>4.62</td>
<td>33.33</td>
<td>5.70</td>
<td>103.60</td>
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<td>Latvia</td>
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<td>2.91</td>
<td>105.32</td>
<td>4.57</td>
<td>57.06</td>
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<td>2.68</td>
<td>55.453</td>
<td>8.58</td>
<td>1,137.91</td>
</tr>
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<td>3.74</td>
<td>129.48</td>
<td>7.48</td>
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<tr>
<td>Average of CEE</td>
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<td>34.61</td>
<td>4.15</td>
<td>109.84</td>
<td>8.32</td>
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<tr>
<td>SEA countries</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indonesia</td>
<td>805.44</td>
<td>4.37</td>
<td>43.06</td>
<td>0.57</td>
<td>59.26</td>
<td>1.23</td>
<td>373.43</td>
</tr>
<tr>
<td>Korea Rep.</td>
<td>9,969.73</td>
<td>4.15</td>
<td>40.76</td>
<td>0.73</td>
<td>66.77</td>
<td>8.13</td>
<td>614.67</td>
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<td>Malaysia</td>
<td>3,649.37</td>
<td>4.11</td>
<td>45.16</td>
<td>4.74</td>
<td>192.85</td>
<td>5.16</td>
<td>128.50</td>
</tr>
<tr>
<td>Philippines</td>
<td>971.05</td>
<td>7.76</td>
<td>32.28</td>
<td>1.61</td>
<td>90.31</td>
<td>0.92</td>
<td>268.97</td>
</tr>
<tr>
<td>Singapore</td>
<td>20,624.57</td>
<td>3.58</td>
<td>34.36</td>
<td>12.78</td>
<td>357.05</td>
<td>14.53</td>
<td>100.43</td>
</tr>
<tr>
<td>Thailand</td>
<td>1,986.84</td>
<td>5.37</td>
<td>40.94</td>
<td>2.35</td>
<td>103.25</td>
<td>3.03</td>
<td>566.92</td>
</tr>
<tr>
<td>Average of SEA</td>
<td>2,392.49</td>
<td>4.40</td>
<td>39.43</td>
<td>3.80</td>
<td>144.91</td>
<td>2.57</td>
<td>396.51</td>
</tr>
</tbody>
</table>

Research Question 2

Q2: What are the over-time percentage changes in macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and percentage changes in per capita emissions (CO\textsubscript{2} and SO\textsubscript{2}) of CEE and SEA countries from 1990 to 2006 or the most recent data available?

GDP per Capita

CEE countries. The percent change of GDP per capita dropped over 9 percent in GDP per capita in the first year of transition to the market system in CEE. The percentage changes in GDP per capita did not stop dropping until 1993, four years after the transition. The GDP per capita in CEE returned to its pre-transition level in 1996, seven years after the reorientation of the economic system to a market economy. The average over-time percentage changes in GDP per capita in CEE were 2.07 percent from 1991 to 2005, which is the most recent data available. Poland, averaging 3.43 percent, and Lithuania, averaging 0.30 percent, were the highest and lowest countries respectively in average over time percentage changes in GDP per capita in this region.

SEA countries. The overall percentage changes in GDP per capita in SEA countries remained stable at around 4 percent annually, with the exception of data from the year 1998, which was the year after Asian Finance Crisis. The percentage change in GDP per capita was -8.24 percent in 1998 in SEA. Korea, averaging 4.88 percent, and the Philippines, averaging 1.25 percent, were the highest and lowest countries respectively in percentage change of GDP per capita in this region from 1990 to 2005, which is the most recent data available.

Figure 4-15 shows the trends of over-time percentage changes in GDP per capita of
these two regions from 1991 to 2005. Figure 4-16 presents the average percentage changes in GDP per capita in each country. Table 4-3 presents a summary of the average overtime percentage changes in GDP per capita in each country and each region, and appears at the end of this section.

![Graph showing average percentage changes in GDP per capita in CEE and SEA countries from 1991 to 2005.](image)

**Figure 4-15.** Average percentage changes in GDP per capita in CEE and SEA countries from 1991 to 2005.

Figure 4-16. Average percentage changes in GDP per capita of each country from 1991 to 2005.


**GDP per Unit of Energy Use**

**CEE countries.** Most of the over-time percentage change of GDP per unit of energy use in CEE countries were positive from 1992 to 2004 with the exception 1996, in which the rate was -1.5 percent. A positive percentage change of GDP per unit of energy use means that these countries consumed greater amounts of energy more and used it more efficiently. It increased an average of 3.76 percent in percentage changes in GDP per unit of energy use from 1991 to 2004, which is the most recent data available, in this region. Estonia, averaging around 7.11 percent, and Slovenia, averaging around 0.7 percent, were the highest and lowest countries respectively in over-time percentage changes in GDP per unit of energy use in this region between 1991 and 2004.
**SEA countries.** The over-time percentage changes in GDP per unit of energy use in SEA countries were quite stable. The changes ranged between positive and negative 3 percent from 1991 to 2004, which is the most recent data available. Singapore, at 2.82 percent, and the Philippines, at -1.14 percent, were the highest and lowest countries respectively in over-time changes of GDP per unit of energy use in this region.

Figure 4-17 shows the trends of over-time percentage changes in GDP per unit of energy use in these two regions from 1991 to 2004. Figure 4-18 presents the average percentage changes in GDP per unit of energy use in each country. Table 4-3 presents a summary of the average overtime percentage changes in GDP per unit of energy use in each country and region, and appears at the end of this section.

![Graph showing percentage changes in GDP per unit of energy use](image)

**Figure 4-17.** Average percentage changes in GDP per unit of energy use in CEE and SEA countries from 1991 to 2004.

Secondary Industry to GDP

CEE countries. The percentage changes in secondary industry to GDP in CEE countries have decreased remarkably for the past 15 years, with the exception of Lithuania. However, the speed of decrease in secondary industry to GDP, or the over-time percentage change of secondary industry to GDP, slowed down after 1994. The average percentage change of secondary industry to GDP was -2.23 percent per year in this area for the past 15 years. Latvia, averaging -4.8 percent from 1990 to 2004, was the highest country in changes of secondary industry to GDP. Unlike most CEE countries, Lithuania increased its percentage changes in secondary industry to GDP. It demonstrated a 1.18 percent growth rate annually in secondary industry to GDP in Lithuania.
**SEA countries.** The over-time percentage changes in secondary industry to GDP in SEA were relatively stable between 1991 and 2005. The over-time percentage changed of secondary industry to GDP in this region averaged roughly positive and negative 4 percent from 1991 to 2005, which is the most recent data available. Most countries in this region increased their secondary industry to GDP share except Korea Republic and Philippines. Philippines dropped around 3 percent annually in over time percentage changes in secondary industry to GDP. Korea Republic dropped slightly 0.1 percent annually. The average change of percentage changes in secondary industry to GDP was 0.59 in this area from 1991 to 2005.

Figure 4-19 shows the trends of over time percentage changes in secondary industry to GDP of CEE and SEA from 1991 to 2005. Figure 4-20 presents the average percentage changes in secondary industry to GDP of each country. Table 4-3 presents a summary of the average overtime percentage changes in secondary industry to GDP in each country and region, and appears at the end of this section.
Figure 4-19. Average percentage changes in secondary industry to GDP in CEE and SEA countries from 1991 to 2005.

Figure 4-20. Average of percentage changes in secondary industry to GDP of each country from 1991 to 2005.


Foreign Direct Investment

CEE countries. The over-time percentage changes in foreign direct investment in CEE were quite stable over the research timeframe, with the exceptions of 1992 and 2003. Even with some years of remarkable decreases, all CEE countries increased, on average, in over-time percentage changes in foreign direct investment to GDP from 1991 to 2005, which is the most recent data available. The average percentage changes in foreign direct investment to GDP increased by 45 percent annually in the area. The Slovak Republic, at around 65 percent, and Hungary, at around 28 percent, are the highest and lowest countries respectively in over-time percentage changes in foreign direct investment to GDP in this region.
**SEA countries.** Most of the over-time percentage changes in foreign direct investment in SEA countries were positive from 1991 to 2005, which is the most recent data available. The average percentage changes in foreign direct investment to GDP increased by 11 percent annually in this area. However, examining the countries individually, Indonesia dropped around 20 percent annually in over-time percentage change of foreign direct investment. Indonesia was the only country in this region with negative percentage changes. In contrast to Indonesia, Malaysia, whose average increase was the highest of all countries in the area in percentage changes in foreign direct investment to GDP, increased over 28 percent annually.

Figure 4-21 presents the trends of overtime percentage changes in foreign direct investment in CEE and SEA from 1991 to 2005. Figure 4-22 shows the percentage changes in foreign direct investment in GDP in each country. Table 4-3 presents a summary of the average percentage changes in foreign direct investment in each country and each region, and appears at the end of this section.
Figure 4-21. Average percentage changes in foreign direct investment to GDP in CEE and SEA countries from 1991 to 2005.

Figure 4-22. Average percentage changes in foreign direct investment to GDP of each country 1991 to 2005.


International Trade

CEE countries. The over-time percentage changes in international trade to GDP in CEE changed remarkably at the beginning years of transform. It dropped by 10 percent in 1991, then increased by 20 and 10 percent in 1992 and 1993 respectively, and then dropped 10 percent in 1994. The average percentage change of international trade to GDP increased 5.74 annually from 1991 to 2005, which is the most recent data available in this area. Lithuania was the country with highest percentage change of international trade to GDP in this region, averaging 13.69 annually. Slovenia, averaging -1.39 annually, had the lowest percentage change in international trade to GDP from 1991 to 2005 among the countries in this region.
SEA countries. The percentage changes in international trade to GDP in SEA were roughly positive and negative 5 percent from 1991 to 2005, which is the most recent data available. The average percentage change increased by 4.6 per year in this area. Indonesia, 8.19 percent per year, had the highest percentage change in international trade to GDP among the countries in this region. Korea Republic and Malaysia were the lowest countries, 3.16 percent every year, in this area.

Figure 4-23 presents the trends in over-time percentage changes in international trade to GDP in CEE and SEA from 1991 to 2005. Figure 4-24 shows the percentage changes in foreign direct investment in GDP in each country. Table 4-3 presents a summary of the average percentage changes in foreign direct investment in each country and each region, and appears at the end of this section.

Figure 4-23. Average percentage changes in international trade to GDP in CEE and SEA countries from 1991 to 2005.

Carbon Dioxide (CO₂)

**CEE countries.** The trend of percentage changes in per capita CO₂ emissions was between positive and negative 5 percent per year from 1991 to 2003, which is the most recent data available. The average change in per capita CO₂ emissions was -2.04 percent per year in this area. All of the countries decreased their per capita CO₂ emissions except Hungary. Latvia, decreased by 4.49 percent per year, was the highest country with respect to decrease in percentage change in per capita CO₂ emissions. Hungary was the only country that demonstrated an increase in percentage change of per capita CO₂ emissions. This increased by 0.05 percent per year on per capita CO₂ emission from 1991 to 2003.
**SEA countries.** In contrast to the CEE, the SEA increased its per capita CO₂ emissions annually, with the exception of 1998, which was the year after Asian Financial Crisis. The annual percentage change in per capita CO₂ emissions was 5.06 percent in this region from 1991 to 2003, which is the most recent data available in this region. Malaysia, at 8.76 percent annually, was the country with the highest increase in percentage change of per capita CO₂ emission in this region. The Philippines, at 3.45 percent, was the country with lowest rate of percentage changes in per capita CO₂ emission in SEA.

Figure 4-25 presents the tendencies of percentage changes in per capita CO₂ emissions in these two groups. Figure 4-26 shows the percentage changes in per capita CO₂ emissions of each country. Table 4-3 presents a summary of the average percentage change in per capita CO₂ emissions of each country and each region, and appears at the end of this section.
Figure 4-25. Average percentage change of per capita CO₂ emissions in CEE and SEA countries from 1991 to 2003.

Figure 4-26. Average percentage change of per capita CO₂ emissions of each country from 1991 to 2003.


Sulphur Dioxide (SO₂)

CEE countries. The percentage changes in per capita SO₂ emissions in CEE were negatively in line with economic expansion from 1991 to 2002, which is the most recent data available in this region. A negative change in the percentage of per capita SO₂ emissions means that emissions of per capita SO₂ lessened at an increasing rate. The average percentage change in per capita SO₂ emissions was -10.18 percent per year in this region. All of the countries decreased their per capita SO₂ emissions from 1991 to 2002. Latvia, at -14.92 percent per year, had the greatest percentage decrease in SO₂ emissions among the countries in this region. Poland, at -6.26 percent per year, had the lowest
percentage decrease in SO₂ emissions among the countries in this region from 1991 to 2002.

**SEA countries.** Unlike CEE, the SEA increased its per capita SO₂ emissions every year, with the exception of 1998, which was the year after Asian Financial Crisis. The annual percentage change in per capita SO₂ emission was 0.43 percent in this region. Most of the countries in this area increased their SO₂ emissions, except for the Korean Republic and Singapore. The Philippines, at 5.88 percent per year, was the country with the highest percentage increase in per capita SO₂ emissions in this region. The Korean Republic, at -6.73 percent per year, was the country with the highest decrease in percentage changes in per capita SO₂ emissions in this area.

Figure 4-27 presents the tendencies of percentage changes in per capita SO₂ emission in these two areas, from 1991 to 2000 in SEA and in 2002 in CEE. Figure 4-28 shows the SO₂ emissions in each country. Table 4-3 presents a summary of the average percentage changes in per capita SO₂ emissions of each country and each region.
Figure 4-27. Average percentage changes in per capita SO$_2$ emissions in CEE and SEA countries from 1991 to 2002 or the most recent data available.

Figure 4-28. Average percentage changes in per capita SO₂ emissions of each country from 1991 to 2002 or the most recent data available.


**Average Percentage Changes in Macroeconomic and Emissions Indicators of CEE and SEA Countries**

The annual average of percentage changes in GDP per capita in CEE and SEA countries increased by 1.96% and 3.45% respectively from 1990 to 2005. That is, in general, the SEA countries increased their income faster than that of in CEE countries from 1990 to 2005 timeframe. However, the CEE was higher in percentage changes in GDP per unit of energy use and percentage changes in foreign direct investment than that of in SEA countries. Table 4-3 presents the average percentage changes in macroeconomic and emissions indicators of CEE and SEA from 1991 to 2005 or the most recent data available.
Table 4-3

Average Percentage Changes in Macroeconomic and Emissions Indicators of CEE and SEA Countries from 1991 to 2005 or the Most Recent Data Available

<table>
<thead>
<tr>
<th>Indicators</th>
<th>CEE countries</th>
<th>SEA countries</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GDP per capita</td>
<td>GDP per unit of energy use</td>
</tr>
<tr>
<td>Czech</td>
<td>1.45</td>
<td>2.29</td>
</tr>
<tr>
<td>Estonia</td>
<td>2.64</td>
<td>6.71</td>
</tr>
<tr>
<td>Hungary</td>
<td>1.70</td>
<td>2.38</td>
</tr>
<tr>
<td>Latvia</td>
<td>0.79</td>
<td>7.09</td>
</tr>
<tr>
<td>Lithuania</td>
<td>0.65</td>
<td>4.18</td>
</tr>
<tr>
<td>Poland</td>
<td>3.57</td>
<td>4.11</td>
</tr>
<tr>
<td>Slovak</td>
<td>2.47</td>
<td>2.69</td>
</tr>
<tr>
<td>Slovenia</td>
<td>2.43</td>
<td>0.84</td>
</tr>
<tr>
<td>Average of CEE</td>
<td>1.96</td>
<td>3.76</td>
</tr>
<tr>
<td>Indonesia</td>
<td>2.99</td>
<td>0.93</td>
</tr>
<tr>
<td>Korea Rep.</td>
<td>4.88</td>
<td>-0.51</td>
</tr>
<tr>
<td>Malaysia</td>
<td>3.89</td>
<td>0.75</td>
</tr>
<tr>
<td>Philippines</td>
<td>1.25</td>
<td>-1.14</td>
</tr>
<tr>
<td>Singapore</td>
<td>4.02</td>
<td>2.82</td>
</tr>
<tr>
<td>Thailand</td>
<td>3.64</td>
<td>-0.32</td>
</tr>
<tr>
<td>Average of SEA</td>
<td>3.45</td>
<td>0.42</td>
</tr>
</tbody>
</table>

Research Question 3

Q3: What are the differences in macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and per capita emissions (CO₂ and SO₂) of CEE versus SEA countries from 1990 to 2006 or the most recent data available?

GDP per Capita

The differences in GDP per capita between CEE and SEA were decreased in the beginning years, when CEE first transitioned to a market system. The differences decreased from around 2000 US dollars (constant 2000 US Dollars, as in all following examples) in 1990 to around 1300 US dollars in 1994. The differences returned to roughly 2000 US dollars in 1998, which was 9 years after the transition to a market economy. The differences became larger and larger from 1998 on. The average difference in the average GDP capita of CEE versus SEA was around 1,900 US dollars from 1990 to 2005.

Figure 4-29 presents the differences in average GDP per capita of CEE versus SEA countries from 1990 to 2005, which is the most recent data available. Table 4-4 presents a summary of the mean differences in average GDP per capita of CEE versus SEA from 1990 to 2005, and appears at the end of this section.
Figure 4-29. The difference of the average GDP per capita of CEE versus SEA countries from 1990 to 2005.


GDP per Unit of Energy Use

The gap in GDP per unit of energy use between CEE and SEA became increasingly smaller between 1990 and 2004; this is the most recent data available. The average GDP per unit of energy use in the CEE, which was 3.5, was remarkably lower than that of the SEA, which was 5.5, in 1992. However, the difference between these two regions lessened as time went by. The GDP per unit of energy use was 4.5 in CEE and 4.8 in SEA in 2002. The differences in GDP per unit of energy use of the CEE versus the SEA decreased from more than 2 constant 2000 purchasing power parity dollar per kg of oil equivalent (this will remain the same in all following examples unless a change is specifically noted) in 1990 to less than 0.25 in 2004. The mean difference in GDP per unit of energy use between CEE and SEA was -1.25 for the 1990 to 2004 timeframe.
Figure 4-30 shows the trend of differences in GDP per unit of energy use between CEE and SEA from 1990 to 2004. Table 4-4 presents a summary of the mean differences in GDP per unit of energy use in these two regions from 1990 to 2004, and appears at the end of this section.

**Figure 4-30.** The difference of the average GDP per capita of energy use of CEE versus SEA countries from 1990 to 2004.


**Secondary Industry to GDP**

The difference of secondary industry to GDP of CEE versus SEA decreased from over 7 percent to around 2 percent from 1990 to 1992. In 1993, the share of secondary industry to GDP in CEE was less than that in SEA. Therefore, the difference became negative after 1993, because CEE had decreased its secondary industry to GDP while SEA had increased it. The differences between these two regions increased from -3 percent in 1993 to -10 percent in 2004. The mean difference of secondary industry to
GDP between CEE and SEA was around -5 percent from 1990 to 2005, which is the most recent data available.

Figure 4-31 shows the trend in differences of secondary industry to GDP per unit of CEE versus SEA from 1990 to 2005. Table 4-4 presents a summary of the mean differences of secondary industry to GDP between CEE and SEA from 1990 to 2005, and appears at the end of this section.

**Figure 4-31.** The difference of the average secondary industry to GDP of CEE versus SEA countries from 1990 to 2005.


**Foreign Direct Investment to GDP**

The differences in foreign direct investment in GDP between CEE and SEA ranged from negative (-3.5 percent in 1990) to positive (2.2 percent in 2005). That is, at the beginning and middle of the 1990s, the contributions of foreign direct investments to
GDP in CEE were less than those of SEA. The trend has revised since 1998. The share of foreign direct investment in GDP in CEE was in excess of that in SEA after 1999. In other words, CEE depended on foreign direct investment to GDP more heavily than SEA did after 1999. The overall average difference was 0.5 percent in these two areas.

Figure 4-32 presents the time trend of the differences in foreign direct investment in GDP between CEE and SEA. Table 4-4 presents a summary of the mean differences of foreign direct investment to GDP of CEE versus SEA from 1990 to 2005, and appears at the end of this section.

Figure 4-32. The difference of the average foreign direct investment to GDP of CEE versus SEA countries from 1990 to 2005.

**International Trade to GDP**

The share of international trade in GDP in CEE was less than that in SEA the full timeframe of the research. The gaps were around -35 percent from 1990 to 2005, with the exception of 1993, which was around -10 percent. In other words, SEA depended on international trade more heavily than CEE did in this timeframe. The average difference between these two regions was -35.28 percent. Figure 4-33 presents the time trend of the differences in international trade to GDP between CEE and SEA. Table 4-4 presents a summary of the mean differences of international trade to GDP between CEE and SEA from 1990 to 2005, and appears at the end of this section.

**Figure 4-33.** The difference of the average international trade to GDP of CEE versus SEA countries from 1990 to 2005.

**Per capita CO₂ emissions**

The differences of per capita CO₂ emissions of CEE versus SEA decreased from around 8 tons per capita in 1990 to 6 tons per capita in 2003, which is the most recent data available. The average differences between these two areas were equal to 5.43 tons per capita. Figure 4-34 shows the differences between these two areas from 1990 to 2003. Table 4-4 presents a summary of the mean of difference of per capita CO₂ emissions of CEE versus SEA from 1990 to 2003, and appears at the end of this section.

![Bar chart showing the difference of per capita CO₂ emissions of CEE versus SEA from 1990 to 2003.](image)

**Figure 4-34.** The difference of the average per capita CO₂ emission of CEE versus SEA countries from 1990 to 2003.

Per capita SO$_2$ emissions

The differences in per capita SO$_2$ emissions between CEE and SEA decreased from 750 kg per capita in 1990 to around 70 kg per capita in 2000, which is the most recent data available. The mean of difference in per capita SO$_2$ emissions was 372.54 kg per capita. Figure 4-35 presents the time trend in the differences of per capita SO$_2$ emissions in these two regions. Table 4-4 presents a summary of the mean differences of per capita SO$_2$ emissions of CEE versus SEA from 1990 to 2000, and appears at the end of this section.

Figure 4-35. The differences of the average per capita SO$_2$ emission of CEE versus SEA countries from 1990 to 2000.

Table 4-4

Summary of the Differences of Average Macroeconomic and Emissions Indicators of CEE versus SEA Counties from 1990 to 2005 or the Most Recent Data Available

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Means Differences</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Macroeconomic</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GDP per capita (constant 2000 US dollars)</td>
<td>1,892.73</td>
<td>426.60</td>
</tr>
<tr>
<td>GDP per capita energy use (constant 2000 PPP dollars per kg of oil equivalent)</td>
<td>-1.21</td>
<td>0.67</td>
</tr>
<tr>
<td>Secondary industry to GDP (%)</td>
<td>-4.87</td>
<td>5.93</td>
</tr>
<tr>
<td>Foreign direct investment (%)</td>
<td>0.14</td>
<td>1.93</td>
</tr>
<tr>
<td>International trade (%)</td>
<td>-35.28</td>
<td>9.33</td>
</tr>
<tr>
<td><strong>Emissions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO₂ (per capita tons)</td>
<td>5.43</td>
<td>2.98</td>
</tr>
<tr>
<td>SO₂ (per capita kg)</td>
<td>372.54</td>
<td>220.68</td>
</tr>
</tbody>
</table>


Results of Hypotheses Testing

*Research Hypothesis 1*

H1: There is a significant curvilinear explanatory relationship among macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and per capita emissions (CO₂ and SO₂) in the CEE countries from 1990 to 2006, or the most recent data available.

H1*: There is a significant curvilinear explanatory relationship among macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and per capita CO₂ emissions in CEE countries from 1990 to 2003, which is the most recent data available.
A multiple regression analysis was applied to test the influences of macroeconomic indicators on per capita CO$_2$ emissions in CEE countries from 1990 to 2003. The number of observations was 99.

The $F$ value (43.17) for the regression model analyzing the six variables was significant ($p = .00$) for an explanatory relationship. The adjusted $R^2$ indicated that the five macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and the quadratic GDP per capita, as a whole explained 72 percent (0.72) of the variance in per capita CO$_2$ emissions in CEE countries from 1990 to 2003.

The $t$-statistic, which is the regression coefficient ($B$) divided by the standard error ($SE$), was applied to analyze the significance of individual predictors on per capita CO$_2$ emissions in CEE. The GDP per capita ($t = 10.17, p = .00$), quadratic GDP per capita ($t = -8.36, p = .00$), GDP per unit of energy use ($t = -13.63, p = .00$), and foreign direct investment ($t = 2.04, p = .04$) were significant, at a .05 level, in explaining per capita CO$_2$ emissions in CEE countries from 1990 to 2003. Secondary industry to GDP ($t = -0.76, p = .45$) and international trade ($t = -1.06, p = .29$) were not significant explanatory variables of per capita CO$_2$ emissions at a .05 significance level.

Based on the absolute values of the $\beta$ coefficients, the order of relative importance of the five macroeconomic indicators and the quadratic GDP per capita was as follows: GDP per capita ($\beta = 3.49$), followed by quadratic GDP per capita ($\beta = -2.65$), GDP per unit of energy use ($\beta = -1.17$), and foreign direct investment ($\beta = 0.13$). Secondary industry to GDP ($\beta = -0.05$) and international trade ($\beta = -0.07$) were not significant
explanatory variables of per capita CO$_2$ emissions in CEE from 1990 to 2003 at the .05 significance level.

In summary, the regression results showed (1) the overall regression model was significant ($F = 43.7$, $p = .00$), explaining a range of 72 percent to 74 percent of the variation in CO$_2$ emissions in CEE. (2) The coefficients of the regression analysis showed a positive relationship between per capita GDP and per capita CO$_2$ emissions and a negative relationship between quadratic GDP per capita and per capita CO$_2$ emissions; and, (3) the $t$-statistic (significance of individual predictors) for GDP per capita ($Y$) and the quadratic of the GDP per capita ($Y^2$) were statistically significant at the .05 level. That is, there was a curvilinear explanatory relationship between GDP per capita and per capita CO$_2$ emissions in CEE from 1990 to 2003. Having met the three conditions, hypothesis 1a was supported. Table 4-5 presents a summary of the results of the multiple regression analysis of macroeconomic indicators in explaining per capita CO$_2$ emissions in CEE from 1990 to 2003.
Table 4-5

Summary of Multiple Regression Analysis for Macroeconomic Indicators in Explaining per capita CO₂ Emissions in CEE Countries from 1990 to 2003 (N = 99)

<table>
<thead>
<tr>
<th>Variables</th>
<th>B</th>
<th>SE</th>
<th>β</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>5.99</td>
<td>1.95</td>
<td>3.08</td>
<td>10.17</td>
<td>.00</td>
</tr>
<tr>
<td>GDP per capita</td>
<td>0.01</td>
<td>0.00</td>
<td>3.49</td>
<td>10.17</td>
<td>.00</td>
</tr>
<tr>
<td>Quadratic GDP per capita</td>
<td>-3.69E-7</td>
<td>0.00</td>
<td>-2.65</td>
<td>-8.36</td>
<td>.00</td>
</tr>
<tr>
<td>GDP per unit of Energy Use</td>
<td>-3.95</td>
<td>0.29</td>
<td>-1.17</td>
<td>-13.63</td>
<td>.00</td>
</tr>
<tr>
<td>Secondary Industry to GDP</td>
<td>-0.03</td>
<td>0.04</td>
<td>-0.05</td>
<td>-0.76</td>
<td>.45</td>
</tr>
<tr>
<td>Foreign Direct Investment</td>
<td>0.12</td>
<td>0.06</td>
<td>0.13</td>
<td>2.04</td>
<td>.04</td>
</tr>
<tr>
<td>International Trade</td>
<td>-0.01</td>
<td>0.01</td>
<td>-0.07</td>
<td>-1.07</td>
<td>.29</td>
</tr>
</tbody>
</table>

F = 43.17  df = 6  p = .00  R² = .74  Adjusted R² = .72.

H₁₀: There is a significant curvilinear explanatory relationship among macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and per capita SO₂ emissions in CEE countries from 1990 to 2002, which is the most recent data available.

The multiple regression analysis was adopted to analyze the influence of macroeconomic indicators on per capita SO₂ emissions in CEE countries from 1990 to 2002. The number of observations was 87.

The F value (22.05) for the regression model analyzing the five variables was significant (p = .00) for an explanatory relationship. The adjusted R² indicated that the five macroeconomic indicators as a whole explained 59 percent (.59) of the variance in per capita SO₂ emissions in CEE countries from 1990 to 2002.
The \( t \)-statistic was applied to analyze the significance of individual predictors on per capita SO\(_2\) emissions in CEE. All of the predictors, except foreign direct investment, were significant at .05 significance levels. GDP per capita \( (t = 2.88, p = .01) \), quadratic GDP per capita \( (t = -3.03, p = .00) \), GDP per unit of energy use \( (t = -2.25, p = .03) \), and international trade \( (t = -8.58, p = .00) \) were significant in explaining per capita SO\(_2\) emissions in CEE from 1990 to 2002. Foreign direct investment \( (t = 0.32, p = .75) \) was not a significant in explaining per capita SO\(_2\) emissions at a .05 significance level.

The order of relative importance, based on the absolute values of the \( \beta \) coefficients, of these five macroeconomic predictors was GDP per capita \( (\beta = 1.34) \), followed by quadratic GDP per capita \( (\beta = -1.33) \), international trade \( (\beta = -0.69) \), GDP per unit of energy use \( (\beta = -0.24) \), and secondary industry to GDP \( (\beta = 0.19) \). Foreign direct investment \( (\beta = -0.03) \) was not a significant explanatory variable of per capita SO\(_2\) emissions in CEE from 1990 to 2002 at a .05 significance level.

The regression results showed: (1) the overall regression model was significant \( (F = 22.05, p = .00) \), explaining 59 percent to 63 percent of the variation in SO\(_2\) emissions of CEE; (2) the coefficients of regression analysis showed a positive relationship between GDP per capita and per capita SO\(_2\) emissions and a negative relationship between quadratic GDP per capita and per capita SO\(_2\) emissions; and, (3) the \( t \)-statistics (significant of individual predictors) for GDP per capita \( (Y) \) and the quadratic of the GDP per capita \( (Y^2) \) were statistically significant at .05 levels. In other words, there was a curvilinear explanatory relationship between GDP per capita and per capita SO\(_2\) emissions in CEE from 1990 to 2002. Having met the three conditions, hypothesis 1b was supported. Table 4-6 presents a summary of the results of the multiple regression analysis.
of macroeconomic indicators in explaining per capita SO$_2$ emissions in CEE from 1990 to 2002.

Table 4-6

*Summary of Multiple Regression Analysis for Macroeconomic Indicators in Explaining per Capita SO$_2$ Emissions in CEE Countries from 1990 to 2002 (N = 87)*

<table>
<thead>
<tr>
<th>Variables</th>
<th>$B$</th>
<th>SE</th>
<th>$\beta$</th>
<th>$t$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>337.36</td>
<td>310.40</td>
<td>1.09</td>
<td>.28</td>
<td></td>
</tr>
<tr>
<td>GDP per capita</td>
<td>0.30</td>
<td>0.11</td>
<td>1.34</td>
<td>2.88</td>
<td>.01</td>
</tr>
<tr>
<td>Quadratic GDP per capita</td>
<td>-2.61E-5</td>
<td>0.00</td>
<td>-1.33</td>
<td>-3.03</td>
<td>.00</td>
</tr>
<tr>
<td>GDP per unit of Energy Use</td>
<td>-106.37</td>
<td>47.19</td>
<td>-0.24</td>
<td>-2.26</td>
<td>.03</td>
</tr>
<tr>
<td>Secondary Industry to GDP</td>
<td>13.20</td>
<td>5.79</td>
<td>0.19</td>
<td>2.28</td>
<td>.03</td>
</tr>
<tr>
<td>Foreign Direct Investment</td>
<td>3.39</td>
<td>10.58</td>
<td>0.03</td>
<td>0.32</td>
<td>.75</td>
</tr>
<tr>
<td>International Trade</td>
<td>-8.07</td>
<td>0.94</td>
<td>-0.69</td>
<td>-8.59</td>
<td>.00</td>
</tr>
</tbody>
</table>

$F = 22.05 \quad df = 6 \quad p = .00 \quad R^2 = .63 \quad$ Adjusted $R^2 = .59.$

*Research Hypothesis 2*

H2: There is a significant curvilinear explanatory relationship among macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and per capita emissions (CO$_2$ and SO$_2$) in the SEA countries from 1990 to 2006, or the most recent data available.

H2$_a$: There is a significant curvilinear explanatory relationship among macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and per capita CO$_2$ emissions in SEA countries from 1990 to 2003, which is the most recent data available.
A multiple regression analysis was applied to analyze the influences of macroeconomic indicators on per capita CO₂ emissions in SEA countries from 1990 to 2003. The number of observations was 83.

The $F$ value (512.27) for the regression model analyzing the six variables was significant ($p = .00$) for an explanatory relationship. The adjusted $R^2$ indicated that the five macroeconomic indicators and the quadratic GDP per capita as a whole explained 97 percent (.97) of the variance in per capita CO₂ emissions in SEA countries from 1990 to 2003.

The $t$-statistic was applied to analyze the significance of individual predictors on per capita CO₂ emissions in SEA. The GDP per capita ($t = 18.64, p = .00$), quadratic GDP per capita ($t = -10.65, p = .00$), GDP per unit of energy use ($t = -3.20, p = .00$), and international trade ($t = 5.51, p = .00$) were significant, at a .05 level, in explaining per capita CO₂ emissions in SEA from 1990 to 2003. Secondary industry to GDP ($t = -1.43, p = .16$) and foreign direct investment ($t = .86, p = .39$) were not significant explanatory variables of per capita CO₂ emissions of SEA at the .05 significance level.

The order of relative importance, based on the absolute values of the $\beta$ coefficients, of these five macroeconomic indicators and the quadratic GDP per capita was as follows: GDP per capita ($\beta = 1.57$), followed by quadratic GDP per capita ($\beta = -0.93$), international trade ($\beta = 0.22$), and GDP per unit of energy use ($\beta = -0.12$). Secondary industry to GDP ($\beta = -0.05$) and foreign direct investment ($\beta = 0.03$) were not significant in explaining the per capita CO₂ emissions in SEA from 1990 to 2003 at a .05 significance level.
In summary, the regression results showed: (1) the overall regression model was significant \( (F = 512.27, p = .00) \), explaining 97% of the variation in CO₂ emissions of SEA; (2) the coefficients of regression analysis showed a positive relationship between GDP per capita and per capita CO₂ emissions and a negative relationship between quadratic GDP per capita and per capita CO₂ emissions; and, (3) the \( t \)-statistics (significant of individual predictors) for GDP per capita \( (Y) \) and the quadratic of the GDP per capita \( (Y^2) \) were statistically significant at .05 levels. In other words, there was a curvilinear explanatory relationship between GDP per capita and CO₂ emissions in SEA from 1990 to 2003. Having met the three conditions, hypothesis 2a was supported.

Table 4-7 presents a summary of the results of the multiple regression analysis of macroeconomic indicators in explaining per capita CO₂ emissions in SEA from 1990 to 2003.

**Table 4-7**

**Summary of Multiple Regression Analysis for Macroeconomic Indicators in Explaining per capita CO₂ Emissions in SEA Countries from 1990 to 2003 \( (N = 83) \)**

<table>
<thead>
<tr>
<th>Variables</th>
<th>( B )</th>
<th>( SE )</th>
<th>( \beta )</th>
<th>( t )</th>
<th>( p )</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>3.65</td>
<td>2.01</td>
<td>1.82</td>
<td>.07</td>
<td></td>
</tr>
<tr>
<td>GDP per capita</td>
<td>0.01E-1</td>
<td>0.00</td>
<td>1.57</td>
<td>18.64</td>
<td>.00</td>
</tr>
<tr>
<td>Quadratic GDP per capita</td>
<td>-3.03E-8</td>
<td>0.00</td>
<td>-0.93</td>
<td>-10.65</td>
<td>.00</td>
</tr>
<tr>
<td>GDP per unit of Energy Use</td>
<td>-0.40</td>
<td>0.13</td>
<td>-0.12</td>
<td>-3.20</td>
<td>.00</td>
</tr>
<tr>
<td>Secondary Industry to GDP</td>
<td>-0.05</td>
<td>0.04</td>
<td>-0.05</td>
<td>-1.43</td>
<td>.15</td>
</tr>
<tr>
<td>Foreign Direct Investment</td>
<td>0.03</td>
<td>0.04</td>
<td>0.03</td>
<td>0.86</td>
<td>.39</td>
</tr>
<tr>
<td>International Trade</td>
<td>-0.01</td>
<td>0.00</td>
<td>0.22</td>
<td>5.51</td>
<td>.00</td>
</tr>
</tbody>
</table>

\( F = 512.27 \quad df = 6 \quad p = .00 \quad R^2 = .97 \quad \text{Adjusted } R^2 = .97 \).
**SEA countries.** The percentage changes in international trade to GDP in SEA were roughly positive and negative 5 percent from 1991 to 2005, which is the most recent data available. The average percentage change increased by 4.6 per year in this area. Indonesia, 8.19 percent per year, had the highest percentage change in international trade to GDP among the countries in this region. Korea Republic and Malaysia were the lowest countries, 3.16 percent every year, in this area.

Figure 4-23 presents the trends in over-time percentage changes in international trade to GDP in CEE and SEA from 1991 to 2005. Figure 4-24 shows the percentage changes in foreign direct investment in GDP in each country. Table 4-3 presents a summary of the average percentage changes in foreign direct investment in each country and each region, and appears at the end of this section.

![Graph showing percentage changes in international trade to GDP in CEE and SEA from 1991 to 2005.](image)

**Figure 4-23.** Average percentage changes in international trade to GDP in CEE and SEA countries from 1991 to 2005.

**Note.** Data for analysis purchased from "World Development Indicator," of The World Bank, 2007.
Figure 4-24. Average percentage changes in international trade to GDP of each country from 1991 to 2005.


Carbon Dioxide (CO₂)

CEE countries. The trend of percentage changes in per capita CO₂ emissions was between positive and negative 5 percent per year from 1991 to 2003, which is the most recent data available. The average change in per capita CO₂ emissions was -2.04 percent per year in this area. All of the countries decreased their per capita CO₂ emissions except Hungary. Latvia, decreased by 4.49 percent per year, was the highest country with respect to decrease in percentage change in per capita CO₂ emissions. Hungary was the only country that demonstrated an increase in percentage change of per capita CO₂ emissions. This increased by 0.05 percent per year on per capita CO₂ emission from 1991 to 2003.
SEA countries. In contrast to the CEE, the SEA increased its per capita CO₂ emissions annually, with the exception of 1998, which was the year after Asian Financial Crisis. The annual percentage change in per capita CO₂ emissions was 5.06 percent in this region from 1991 to 2003, which is the most recent data available in this region. Malaysia, at 8.76 percent annually, was the country with the highest increase in percentage change of per capita CO₂ emission in this region. The Philippines, at 3.45 percent, was the country with lowest rate of percentage changes in per capita CO₂ emission in SEA.

Figure 4-25 presents the tendencies of percentage changes in per capita CO₂ emissions in these two groups. Figure 4-26 shows the percentage changes in per capita CO₂ emissions of each country. Table 4-3 presents a summary of the average percentage change in per capita CO₂ emissions of each country and each region, and appears at the end of this section.
Figure 4-25. Average percentage change of per capita CO$_2$ emissions in CEE and SEA countries from 1991 to 2003.

Figure 4-26. Average percentage change of per capita CO₂ emissions of each country from 1991 to 2003.


Sulphur Dioxide (SO₂)

**CEE countries.** The percentage changes in per capita SO₂ emissions in CEE were negatively in line with economic expansion from 1991 to 2002, which is the most recent data available in this region. A negative change in the percentage of per capita SO₂ emissions means that emissions of per capita SO₂ lessened at an increasing rate. The average percentage change in per capita SO₂ emissions was -10.18 percent per year in this region. All of the countries decreased their per capita SO₂ emissions from 1991 to 2002. Latvia, at -14.92 percent per year, had the greatest percentage decrease in SO₂ emissions among the countries in this region. Poland, at -6.26 percent per year, had the lowest
percentage decrease in SO₂ emissions among the countries in this region from 1991 to 2002.

**SEA countries.** Unlike CEE, the SEA increased its per capita SO₂ emissions every year, with the exception of 1998, which was the year after Asian Financial Crisis. The annual percentage change in per capita SO₂ emission was 0.43 percent in this region. Most of the countries in this area increased their SO₂ emissions, except for the Korean Republic and Singapore. The Philippines, at 5.88 percent per year, was the country with the highest percentage increase in per capita SO₂ emissions in this region. The Korean Republic, at -6.73 percent per year, was the country with the highest decrease in percentage changes in per capita SO₂ emissions in this area.

Figure 4-27 presents the tendencies of percentage changes in per capita SO₂ emission in these two areas, from 1991 to 2000 in SEA and in 2002 in CEE. Figure 4-28 shows the SO₂ emissions in each country. Table 4-3 presents a summary of the average percentage changes in per capita SO₂ emissions of each country and each region.
Figure 4-27. Average percentage changes in per capita SO₂ emissions in CEE and SEA countries from 1991 to 2002 or the most recent data available.

Figure 4-28. Average percentage changes in per capita SO2 emissions of each country from 1991 to 2002 or the most recent data available.


Average Percentage Changes in Macroeconomic and Emissions Indicators of CEE and SEA Countries

The annual average of percentage changes in GDP per capita in CEE and SEA countries increased by 1.96% and 3.45% respectively from 1990 to 2005. That is, in general, the SEA countries increased their income faster than that of in CEE countries from 1990 to 2005 timeframe. However, the CEE was higher in percentage changes in GDP per unit of energy use and percentage changes in foreign direct investment than that of in SEA countries. Table 4-3 presents the average percentage changes in macroeconomic and emissions indicators of CEE and SEA from 1991 to 2005 or the most recent data available.
Table 4-3

Average Percentage Changes in Macroeconomic and Emissions Indicators of CEE and SEA Countries from 1991 to 2005 or the Most Recent Data Available

<table>
<thead>
<tr>
<th></th>
<th>Macroeconomic</th>
<th>Emission</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GDP per capita</td>
<td>GDP per unit of energy use</td>
</tr>
<tr>
<td><strong>CEE countries</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Czech</td>
<td>1.45</td>
<td>2.29</td>
</tr>
<tr>
<td>Estonia</td>
<td>2.64</td>
<td>6.71</td>
</tr>
<tr>
<td>Hungary</td>
<td>1.70</td>
<td>2.38</td>
</tr>
<tr>
<td>Latvia</td>
<td>0.79</td>
<td>7.09</td>
</tr>
<tr>
<td>Lithuania</td>
<td>0.65</td>
<td>4.18</td>
</tr>
<tr>
<td>Poland</td>
<td>3.57</td>
<td>4.11</td>
</tr>
<tr>
<td>Slovak</td>
<td>2.47</td>
<td>2.69</td>
</tr>
<tr>
<td>Slovenia</td>
<td>2.43</td>
<td>0.84</td>
</tr>
<tr>
<td><strong>Average of CEE</strong></td>
<td><strong>1.96</strong></td>
<td><strong>3.76</strong></td>
</tr>
<tr>
<td><strong>SEA countries</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indonesia</td>
<td>2.99</td>
<td>0.93</td>
</tr>
<tr>
<td>Korea Rep.</td>
<td>4.88</td>
<td>-0.51</td>
</tr>
<tr>
<td>Malaysia</td>
<td>3.89</td>
<td>0.75</td>
</tr>
<tr>
<td>Philippines</td>
<td>1.25</td>
<td>-1.14</td>
</tr>
<tr>
<td>Singapore</td>
<td>4.02</td>
<td>2.82</td>
</tr>
<tr>
<td>Thailand</td>
<td>3.64</td>
<td>-0.32</td>
</tr>
<tr>
<td><strong>Average of SEA</strong></td>
<td><strong>3.45</strong></td>
<td><strong>0.42</strong></td>
</tr>
</tbody>
</table>

Research Question 3

Q3: What are the differences in macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and per capita emissions (CO₂ and SO₂) of CEE versus SEA countries from 1990 to 2006 or the most recent data available?

GDP per Capita

The differences in GDP per capita between CEE and SEA were decreased in the beginning years, when CEE first transitioned to a market system. The differences decreased from around 2000 US dollars (constant 2000 US Dollars, as in all following examples) in 1990 to around 1300 US dollars in 1994. The differences returned to roughly 2000 US dollars in 1998, which was 9 years after the transition to a market economy. The differences became larger and larger from 1998 on. The average difference in the average GDP capita of CEE versus SEA was around 1,900 US dollars from 1990 to 2005.

Figure 4-29 presents the differences in average GDP per capita of CEE versus SEA countries from 1990 to 2005, which is the most recent data available. Table 4-4 presents a summary of the mean differences in average GDP per capita of CEE versus SEA from 1990 to 2005, and appears at the end of this section.
The difference of the average GDP per capita of CEE versus SEA countries from 1990 to 2005.


**GDP per Unit of Energy Use**

The gap in GDP per unit of energy use between CEE and SEA became increasingly smaller between 1990 and 2004; this is the most recent data available. The average GDP per unit of energy use in the CEE, which was 3.5, was remarkably lower than that of the SEA, which was 5.5, in 1992. However, the difference between these two regions lessened as time went by. The GDP per unit of energy use was 4.5 in CEE and 4.8 in SEA in 2002. The differences in GDP per unit of energy use of the CEE versus the SEA decreased from more than 2 constant 2000 purchasing power parity dollar per kg of oil equivalent (this will remain the same in all following examples unless a change is specifically noted) in 1990 to less than 0.25 in 2004. The mean difference in GDP per unit of energy use between CEE and SEA was -1.25 for the 1990 to 2004 timeframe.
Figure 4-30 shows the trend of differences in GDP per unit of energy use between CEE and SEA from 1990 to 2004. Table 4-4 presents a summary of the mean differences in GDP per unit of energy use in these two regions from 1990 to 2004, and appears at the end of this section.

![Graph showing the trend of differences in GDP per unit of energy use between CEE and SEA from 1990 to 2004.](image)

**Figure 4-30.** The difference of the average GDP per capita of energy use of CEE versus SEA countries from 1990 to 2004.


**Secondary Industry to GDP**

The difference of secondary industry to GDP of CEE versus SEA decreased from over 7 percent to around 2 percent from 1990 to 1992. In 1993, the share of secondary industry to GDP in CEE was less than that in SEA. Therefore, the difference became negative after 1993, because CEE had decreased its secondary industry to GDP while SEA had increased it. The differences between these two regions increased from -3 percent in 1993 to -10 percent in 2004. The mean difference of secondary industry to
GDP between CEE and SEA was around -5 percent from 1990 to 2005, which is the most recent data available.

Figure 4-31 shows the trend in differences of secondary industry to GDP per unit of CEE versus SEA from 1990 to 2005. Table 4-4 presents a summary of the mean differences of secondary industry to GDP between CEE and SEA from 1990 to 2005, and appears at the end of this section.

**Figure 4-31.** The difference of the average secondary industry to GDP of CEE versus SEA countries from 1990 to 2005.


**Foreign Direct Investment to GDP**

The differences in foreign direct investment in GDP between CEE and SEA ranged from negative (-3.5 percent in 1990) to positive (2.2 percent in 2005). That is, at the beginning and middle of the 1990s, the contributions of foreign direct investments to
GDP in CEE were less than those of SEA. The trend has revised since 1998. The share of foreign direct investment in GDP in CEE was in excess of that in SEA after 1999. In other words, CEE depended on foreign direct investment to GDP more heavily than SEA did after 1999. The overall average difference was 0.5 percent in these two areas.

Figure 4-32 presents the time trend of the differences in foreign direct investment in GDP between CEE and SEA. Table 4-4 presents a summary of the mean differences of foreign direct investment to GDP of CEE versus SEA from 1990 to 2005, and appears at the end of this section.

![Figure 4-32. The difference of the average foreign direct investment to GDP of CEE versus SEA countries from 1990 to 2005.](image)

International Trade to GDP

The share of international trade in GDP in CEE was less than that in SEA the full timeframe of the research. The gaps were around -35 percent from 1990 to 2005, with the exception of 1993, which was around -10 percent. In other words, SEA depended on international trade more heavily than CEE did in this timeframe. The average difference between these two regions was -35.28 percent. Figure 4-33 presents the time trend of the differences in international trade to GDP between CEE and SEA. Table 4-4 presents a summary of the mean differences of international trade to GDP between CEE and SEA from 1990 to 2005, and appears at the end of this section.

Figure 4-33. The difference of the average international trade to GDP of CEE versus SEA countries from 1990 to 2005.

Per capita CO\textsubscript{2} emissions

The differences of per capita CO\textsubscript{2} emissions of CEE versus SEA decreased from around 8 tons per capita in 1990 to 6 tons per capita in 2003, which is the most recent data available. The average differences between these two areas were equal to 5.43 tons per capita. Figure 4-34 shows the differences between these two areas from 1990 to 2003. Table 4-4 presents a summary of the mean of difference of per capita CO\textsubscript{2} emissions of CEE versus SEA from 1990 to 2003, and appears at the end of this section.

Figure 4-34. The difference of the average per capita CO\textsubscript{2} emission of CEE versus SEA countries from 1990 to 2003.

Per capita $SO_2$ emissions

The differences in per capita $SO_2$ emissions between CEE and SEA decreased from 750 kg per capita in 1990 to around 70 kg per capita in 2000, which is the most recent data available. The mean of difference in per capita $SO_2$ emissions was 372.54 kg per capita. Figure 4-35 presents the time trend in the differences of per capita $SO_2$ emissions in these two regions. Table 4-4 presents a summary of the mean differences of per capita $SO_2$ emissions of CEE versus SEA from 1990 to 2000, and appears at the end of this section.

Figure 4-35. The differences of the average per capita $SO_2$ emission of CEE versus SEA countries from 1990 to 2000.

Table 4-4

*Summary of the Differences of Average Macroeconomic and Emissions Indicators of CEE versus SEA Counties from 1990 to 2005 or the Most Recent Data Available*

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Means Differences</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Macroeconomic</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GDP per capita (constant 2000 US dollars)</td>
<td>1,892.73</td>
<td>426.60</td>
</tr>
<tr>
<td>GDP per capita energy use (constant 2000 PPP dollars per kg of oil equivalent)</td>
<td>-1.21</td>
<td>0.67</td>
</tr>
<tr>
<td>Secondary industry to GDP (%)</td>
<td>-4.87</td>
<td>5.93</td>
</tr>
<tr>
<td>Foreign direct investment (%)</td>
<td>0.14</td>
<td>1.93</td>
</tr>
<tr>
<td>International trade (%)</td>
<td>-35.28</td>
<td>9.33</td>
</tr>
<tr>
<td><strong>Emissions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO₂ (per capita tons)</td>
<td>5.43</td>
<td>2.98</td>
</tr>
<tr>
<td>SO₂ (per capita kg)</td>
<td>372.54</td>
<td>220.68</td>
</tr>
</tbody>
</table>


**Results of Hypotheses Testing**

*Research Hypothesis 1*

**H₁:** There is a significant curvilinear explanatory relationship among macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and per capita emissions (CO₂ and SO₂) in the CEE countries from 1990 to 2006, or the most recent data available.

**H₁ₐ:** There is a significant curvilinear explanatory relationship among macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and per capita CO₂ emissions in CEE countries from 1990 to 2003, which is the most recent data available.
A multiple regression analysis was applied to test the influences of macroeconomic indicators on per capita CO$_2$ emissions in CEE countries from 1990 to 2003. The number of observations was 99.

The $F$ value (43.17) for the regression model analyzing the six variables was significant ($p = .00$) for an explanatory relationship. The adjusted $R^2$ indicated that the five macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and the quadratic GDP per capita, as a whole explained 72 percent (.72) of the variance in per capita CO$_2$ emissions in CEE countries from 1990 to 2003.

The $t$-statistic, which is the regression coefficient ($B$) divided by the standard error (SE), was applied to analyze the significance of individual predictors on per capita CO$_2$ emissions in CEE. The GDP per capita ($t = 10.17, p = .00$), quadratic GDP per capita ($t = -8.36, p = .00$), GDP per unit of energy use ($t = -13.63, p = .00$), and foreign direct investment ($t = 2.04, p = .04$) were significant, at a .05 level, in explaining per capita CO$_2$ emissions in CEE countries from 1990 to 2003. Secondary industry to GDP ($t = -0.76, p = .45$) and international trade ($t = -1.06, p = .29$) were not significant explanatory variables of per capita CO$_2$ emissions at a .05 significance level.

Based on the absolute values of the $\beta$ coefficients, the order of relative importance of the five macroeconomic indicators and the quadratic GDP per capita was as follows: GDP per capita ($\beta = 3.49$), followed by quadratic GDP per capita ($\beta = -2.65$), GDP per unit of energy use ($\beta = -1.17$), and foreign direct investment ($\beta = 0.13$). Secondary industry to GDP ($\beta = -0.05$) and international trade ($\beta = -0.07$) were not significant.
explanatory variables of per capita CO\textsubscript{2} emissions in CEE from 1990 to 2003 at the .05 significance level.

In summary, the regression results showed (1) the overall regression model was significant ($F=43.7, \ p=.00$), explaining a range of 72 percent to 74 percent of the variation in CO\textsubscript{2} emissions in CEE. (2) The coefficients of the regression analysis showed a positive relationship between per capita GDP and per capita CO\textsubscript{2} emissions and a negative relationship between quadratic GDP per capita and per capita CO\textsubscript{2} emissions; and, (3) the $t$-statistic (significance of individual predictors) for GDP per capita ($Y$) and the quadratic of the GDP per capita ($Y^2$) were statistically significant at the .05 level. That is, there was a curvilinear explanatory relationship between GDP per capita and per capita CO\textsubscript{2} emissions in CEE from 1990 to 2003. Having met the three conditions, hypothesis 1a was supported. Table 4-5 presents a summary of the results of the multiple regression analysis of macroeconomic indicators in explaining per capita CO\textsubscript{2} emissions in CEE from 1990 to 2003.
Summary of Multiple Regression Analysis for Macroeconomic Indicators in Explaining per capita CO₂ Emissions in CEE Countries from 1990 to 2003 (N = 99)

<table>
<thead>
<tr>
<th>Variables</th>
<th>B</th>
<th>SE</th>
<th>β</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>5.99</td>
<td>1.95</td>
<td>3.08</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>GDP per capita</td>
<td>0.01</td>
<td>0.00</td>
<td>3.49</td>
<td>10.17</td>
<td>0.00</td>
</tr>
<tr>
<td>Quadratic GDP per capita</td>
<td>-3.69E-7</td>
<td>0.00</td>
<td>-2.65</td>
<td>-8.36</td>
<td>0.00</td>
</tr>
<tr>
<td>GDP per unit of Energy Use</td>
<td>-3.95</td>
<td>0.29</td>
<td>-1.17</td>
<td>-13.63</td>
<td>0.00</td>
</tr>
<tr>
<td>Secondary Industry to GDP</td>
<td>-0.03</td>
<td>0.04</td>
<td>-0.05</td>
<td>-0.76</td>
<td>0.45</td>
</tr>
<tr>
<td>Foreign Direct Investment</td>
<td>0.12</td>
<td>0.06</td>
<td>0.13</td>
<td>2.04</td>
<td>0.04</td>
</tr>
<tr>
<td>International Trade</td>
<td>-0.01</td>
<td>0.01</td>
<td>-0.07</td>
<td>-1.07</td>
<td>0.29</td>
</tr>
</tbody>
</table>

F = 43.17  df = 6  p = .00  R² = .74  Adjusted R² = .72.

H₁b: There is a significant curvilinear explanatory relationship among macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and per capita SO₂ emissions in CEE countries from 1990 to 2002, which is the most recent data available.

The multiple regression analysis was adopted to analyze the influence of macroeconomic indicators on per capita SO₂ emissions in CEE countries from 1990 to 2002. The number of observations was 87.

The F value (22.05) for the regression model analyzing the five variables was significant (p = .00) for an explanatory relationship. The adjusted R² indicated that the five macroeconomic indicators as a whole explained 59 percent (.59) of the variance in per capita SO₂ emissions in CEE countries from 1990 to 2002.
The $t$-statistic was applied to analyze the significance of individual predictors on per capita SO$_2$ emissions in CEE. All of the predictors, except foreign direct investment, were significant at .05 significance levels. GDP per capita ($t = 2.88, p = .01$), quadratic GDP per capita ($t = -3.03, p = .00$), GDP per unit of energy use ($t = -2.25, p = .03$), and international trade ($t = -8.58, p = .00$) were significant in explaining per capita SO$_2$ emissions in CEE from 1990 to 2002. Foreign direct investment ($t = 0.32, p = .75$) was not a significant in explaining per capita SO$_2$ emissions at a .05 significance level.

The order of relative importance, based on the absolute values of the $\beta$ coefficients, of these five macroeconomic predictors was GDP per capita ($\beta = 1.34$), followed by quadratic GDP per capita ($\beta = -1.33$), international trade ($\beta = -.69$), GDP per unit of energy use ($\beta = -.24$), and secondary industry to GDP ($\beta = .19$). Foreign direct investment ($\beta = -.03$) was not a significant explanatory variable of per capita SO$_2$ emissions in CEE from 1990 to 2002 at a .05 significance level.

The regression results showed: (1) the overall regression model was significant ($F = 22.05, p = .00$), explaining 59 percent to 63 percent of the variation in SO$_2$ emissions of CEE; (2) the coefficients of regression analysis showed a positive relationship between GDP per capita and per capita SO$_2$ emissions and a negative relationship between quadratic GDP per capita and per capita SO$_2$ emissions; and, (3) the $t$-statistics (significant of individual predictors) for GDP per capita ($Y$) and the quadratic of the GDP per capita ($Y^2$) were statistically significant at .05 levels. In other words, there was a curvilinear explanatory relationship between GDP per capita and per capita SO$_2$ emissions in CEE from 1990 to 2002. Having met the three conditions, hypothesis 1b was supported. Table 4-6 presents a summary of the results of the multiple regression analysis.
of macroeconomic indicators in explaining per capita SO₂ emissions in CEE from 1990 to 2002.

Table 4-6

*Summary of Multiple Regression Analysis for Macroeconomic Indicators in Explaining per Capita SO₂ Emissions in CEE Countries from 1990 to 2002 (N = 87)*

<table>
<thead>
<tr>
<th>Variables</th>
<th>B</th>
<th>SE</th>
<th>β</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>337.36</td>
<td>310.40</td>
<td>1.09</td>
<td>2.88</td>
<td>.01</td>
</tr>
<tr>
<td>GDP per capita</td>
<td>0.30</td>
<td>0.11</td>
<td>1.34</td>
<td>-1.33</td>
<td>-3.03</td>
</tr>
<tr>
<td>Quadratic GDP per capita</td>
<td>-2.61E-5</td>
<td>0.00</td>
<td>-1.33</td>
<td>-3.03</td>
<td>.00</td>
</tr>
<tr>
<td>GDP per unit of Energy Use</td>
<td>-106.37</td>
<td>47.19</td>
<td>-0.24</td>
<td>2.28</td>
<td>.03</td>
</tr>
<tr>
<td>Secondary Industry to GDP</td>
<td>13.20</td>
<td>5.79</td>
<td>0.19</td>
<td>2.28</td>
<td>.03</td>
</tr>
<tr>
<td>Foreign Direct Investment</td>
<td>3.39</td>
<td>10.58</td>
<td>0.03</td>
<td>0.32</td>
<td>.75</td>
</tr>
<tr>
<td>International Trade</td>
<td>-8.07</td>
<td>0.94</td>
<td>-0.69</td>
<td>-8.59</td>
<td>.00</td>
</tr>
</tbody>
</table>

\[ F = 22.05 \quad df = 6 \quad p = .00 \quad R^2 = .63 \quad \text{Adjusted } R^2 = .59.\]

**Research Hypothesis 2**

H2: There is a significant curvilinear explanatory relationship among macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and per capita emissions (CO₂ and SO₂) in the SEA countries from 1990 to 2006, or the most recent data available.

H2ₐ: There is a significant curvilinear explanatory relationship among macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and per capita CO₂ emissions in SEA countries from 1990 to 2003, which is the most recent data available.
A multiple regression analysis was applied to analyze the influences of macroeconomic indicators on per capita CO₂ emissions in SEA countries from 1990 to 2003. The number of observations was 83.

The $F$ value (512.27) for the regression model analyzing the six variables was significant ($p = .00$) for an explanatory relationship. The adjusted $R^2$ indicated that the five macroeconomic indicators and the quadratic GDP per capita as a whole explained 97 percent (.97) of the variance in per capita CO₂ emissions in SEA countries from 1990 to 2003.

The $t$-statistic was applied to analyze the significance of individual predictors on per capita CO₂ emissions in SEA. The GDP per capita ($t = 18.64, p = .00$), quadratic GDP per capita ($t = -10.65, p = .00$), GDP per unit of energy use ($t = -3.20, p = .00$), and international trade ($t = 5.51, p = .00$) were significant, at a .05 level, in explaining per capita CO₂ emissions in SEA from 1990 to 2003. Secondary industry to GDP ($t = -1.43, p = .16$) and foreign direct investment ($t = .86, p = .39$) were not significant explanatory variables of per capita CO₂ emissions of SEA at the .05 significance level.

The order of relative importance, based on the absolute values of the $\beta$ coefficients, of these five macroeconomic indicators and the quadratic GDP per capita was as follows: GDP per capita ($\beta = 1.57$), followed by quadratic GDP per capita ($\beta = -.93$), international trade ($\beta = .22$), and GDP per unit of energy use ($\beta = -.12$). Secondary industry to GDP ($\beta = -.05$) and foreign direct investment ($\beta = .03$) were not significant in explaining the per capita CO₂ emissions in SEA from 1990 to 2003 at a .05 significance level.
In summary, the regression results showed: (1) the overall regression model was significant \((F = 512.27, p = .00)\), explaining 97\% of the variation in \(\text{CO}_2\) emissions of SEA; (2) the coefficients of regression analysis showed a positive relationship between GDP per capita and per capita \(\text{CO}_2\) emissions and a negative relationship between quadratic GDP per capita and per capita \(\text{CO}_2\) emissions; and, (3) the \(t\)-statistics (significant of individual predictors) for GDP per capita \((Y)\) and the quadratic of the GDP per capita \((Y^2)\) were statistically significant at .05 levels. In other words, there was a curvilinear explanatory relationship between GDP per capita and \(\text{CO}_2\) emissions in SEA from 1990 to 2003. Having met the three conditions, hypothesis 2a was supported.

Table 4-7 presents a summary of the results of the multiple regression analysis of macroeconomic indicators in explaining per capita \(\text{CO}_2\) emissions in SEA from 1990 to 2003.

Table 4-7

<table>
<thead>
<tr>
<th>Variables</th>
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<th>(\beta)</th>
<th>(t)</th>
<th>(p)</th>
</tr>
</thead>
<tbody>
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<td>2.01</td>
<td>1.82</td>
<td>.07</td>
<td></td>
</tr>
<tr>
<td>GDP per capita</td>
<td>0.01E-1</td>
<td>0.00</td>
<td>1.57</td>
<td>18.64</td>
<td>.00</td>
</tr>
<tr>
<td>Quadratic GDP per capita</td>
<td>.303E-8</td>
<td>0.00</td>
<td>-0.93</td>
<td>-10.65</td>
<td>.00</td>
</tr>
<tr>
<td>GDP per unit of Energy Use</td>
<td>-0.40</td>
<td>0.13</td>
<td>-0.12</td>
<td>-3.20</td>
<td>.00</td>
</tr>
<tr>
<td>Secondary Industry to GDP</td>
<td>-0.05</td>
<td>0.04</td>
<td>-0.05</td>
<td>-1.43</td>
<td>.15</td>
</tr>
<tr>
<td>Foreign Direct Investment</td>
<td>0.03</td>
<td>0.04</td>
<td>0.03</td>
<td>0.86</td>
<td>.39</td>
</tr>
<tr>
<td>International Trade</td>
<td>-0.01</td>
<td>0.00</td>
<td>0.22</td>
<td>5.51</td>
<td>.00</td>
</tr>
</tbody>
</table>

\(F = 512.27 \quad df = 6 \quad p = .00 \quad R^2 = .97 \quad \text{Adjusted } R^2 = .97\)
H2b: There is a significant curvilinear explanatory relationship among microeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and per capita SO$_2$ emissions in SEA countries from 1990 to 2000, which is the most recent data available.

The multiple regression analysis was applied to analyze the influences of macroeconomic indicators on per capita SO$_2$ emissions in SEA countries from 1990 to 2000. The number of observations was 65.

The $F$ value (19.55) for the regression model analyzing the five variables was significant ($p = .00$) for an explanatory relationship. The adjusted $R^2$ indicated that the five macroeconomic indicators as a whole explained 63 percent (.63) of the variance in per capita SO$_2$ emissions in SEA countries from 1990 to 2000.

The $t$-statistic tested the significance of individual predictors on per capita SO$_2$ emissions in SEA. GDP per capita ($t = 2.92$, $p = .01$) and international trade ($t = -5.65$, $p = .00$) were significant in explaining per capita SO$_2$ emissions in SEA from 1990 to 2000. Quadratic GDP per capita ($t = -1.15$, $p = .26$), GDP per unit of energy use ($t = 0.37$, $p = .71$), secondary industry to GDP ($t = 1.26$, $p = .21$), and foreign direct investment ($t = -0.60$, $p = .55$) were not significant explanatory variables of per capita SO$_2$ emissions at a .05 significance level.

The order of relative importance, based on the absolute values of the $\beta$ coefficients, of these five macroeconomic predictors was as follows: GDP per capita ($\beta = 1.04$) and international trade ($\beta = -1.00$). Quadratic GDP per capita ($\beta = -.43$), GDP per unit of energy use ($\beta = .06$), secondary industry to GDP ($\beta = .16$), and foreign direct investment
(β = -.11) were not significant in explaining the per capita SO₂ emissions in SEA from 1990 to 2000 at the .05 significance level.

The regression results showed: (1) the overall regression model was significant ($F = 19.55, p = .00$), explaining 63% to 67% of the variation in per capita SO₂ emissions in SEA from 1990 to 2000; (2) the coefficients of regression analysis showed a positive and significant relationship between GDP per capita and per capita SO₂ emissions in SEA from 1990 to 2000, and the coefficients of regression analysis also showed a negative relationship between quadratic GDP per capita and per capita SO₂ emissions in SEA from 1990 to 2000; however, (3) the coefficient of quadratic GDP per capita was not statistically significant, at the .05 significance level, in explaining per capita SO₂ emissions in SEA from 1990 to 2000. Having only met two of three conditions, hypothesis 2b was only partially supported. Table 4-8 presents a summary of the results of the multiple regression analysis of macroeconomic indicators in explaining per capita SO₂ emissions in SEA from 1990 to 2000.

Table 4-8

| Summary of Multiple Regression Analysis for Macroeconomic Indicators Explaining per capita SO₂ Emissions in SEA Countries from 1990 to 2000 (N = 65) |
|---|---|---|---|---|---|
| Variables | B | SE | β | t | p |
| (Constant) | 152.90 | 359.36 | 0.43 | .67 |
| GDP per capita | 0.03 | 0.01 | 1.04 | 2.92 | .01 |
| Quadratic GDP per capita | -6.55E-7 | 0.00 | -0.43 | -1.15 | .26 |
| GDP per unit of Energy Use | 8.21 | 21.70 | 0.06 | 0.38 | .71 |
| Secondary Industry to GDP | 7.95 | 6.33 | 0.16 | 1.26 | .21 |
| Foreign Direct Investment | -4.75 | 7.90 | -0.11 | -0.60 | .55 |
| International Trade | -2.10 | 0.37 | -1.00 | -5.64 | .00 |

$F = 19.55$  $df = 6$  $p = .00$  $R^2 = .67$  Adjusted $R^2 = .63$. 

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**Research Hypothesis 3**

H3: There is a significant curvilinear explanatory relationship among the percentage change in macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and the percentage change in per capita emissions (CO$_2$ and SO$_2$) of CEE countries from 1990 to 2006, or the most recent data available.

H3$_a$: There is a significant curvilinear explanatory relationship among the percentage change in macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and the percentage change in per capita CO$_2$ emissions in CEE countries from 1990 to 2003, which is the most recent data available.

A multiple regression analysis was applied to analyze the influences of percentage change of each macroeconomic indicator on percentage change in per capita CO$_2$ emissions of CEE countries from 1990 to 2003. The number of observations was 99.

The $F$ value (92.62) for the regression model analyzing the five variables was significant ($p = .00$) for an explanatory relationship. The adjusted $R^2$ indicated that the percentage changes in five macroeconomic indicators as a whole explained 85 percent (.85) of the variance in percentage changes in per capita CO$_2$ emissions in CEE countries from 1991 to 2003.

The $t$-statistic, which is the regression coefficient ($B$) divided by the standard error ($SE$), tested the significance of percentage changes in individual predictors on percentage changes in per capita CO$_2$ emissions in CEE from 1990 to 2003. All the percentage changes in five macroeconomic indicators and percentage changes in quadratic GDP per
capita in explaining percentage changes in per capita CO₂ emissions were significant at .05 significance levels. The $t$-statistics of each predictions were as follows: percentage changes in GDP per capita ($t = 8.28, p = .00$), percentage changes in quadratic GDP per capita ($t = -7.70, p = .00$), percentage changes in GDP per unit of energy use ($t = -19.51, p = .00$), percentage changes in secondary industry to GDP ($t = 3.09, p = .00$), percentage changes in foreign direct investment ($t = 4.04, p = .00$), and percentage changes in international trade ($t = -2.67, p = .01$) from 1990 to 2003.

Based on the absolute values of the $β$ coefficients, the order of relative importance of these five macroeconomic predictors was as follows: percentage changes in GDP per capita ($β = 13.70$), followed by percentage changes in quadratic GDP per capita ($β = -12.68$), percentage changes in GDP per unit of energy use ($β = -.20$), percentage changes in foreign direct investment ($β = .13$), percentage changes in secondary industry to GDP ($β = .16$), and percentage changes in international trade ($β = -.12$).

The regression results showed that (1) the overall regression model was significant ($F = 92.62, p = .00$), explaining 85% to 86% of the variation in percentage change in per capita CO₂ emissions in CEE; (2) the coefficients of regression analysis showed a positive relationship between percentage change in GDP per capita and percentage changes in per capita CO₂ emissions and a negative relationship between percentage changes in quadratic GDP per capita and percentage changes in per capita CO₂ emissions; and (3) the $t$-statistics (significant of individual predictors) for percentage changes in GDP per capita ($lnY$) and the percentage changes in quadratic GDP per capita ($lnY)^2$ were statistically significant at .05 levels. Having met the three conditions, hypothesis 3a was supported.
Table 4-9 presents a summary of the results of the multiple regression analysis of percentage changes in macroeconomic indicators in explaining percentage changes in per capita CO₂ emissions in CEE from 1990 to 2003.

Table 4-9

Summary of Multiple Regression Analysis for Percentage Changes in Macroeconomic Indicators Explaining Percentage Changes in Per Capita CO₂ Emissions in CEE Countries from 1990 to 2003 (N = 99)

<table>
<thead>
<tr>
<th>Variables</th>
<th>B</th>
<th>SE</th>
<th>β</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>-71.85</td>
<td>8.50</td>
<td>8.45</td>
<td>.00</td>
<td></td>
</tr>
<tr>
<td>GDP per capita</td>
<td>16.65</td>
<td>2.01</td>
<td>13.70</td>
<td>8.28</td>
<td>.00</td>
</tr>
<tr>
<td>Quadratic GDP per capita</td>
<td>-0.91</td>
<td>0.12</td>
<td>-12.68</td>
<td>-7.70</td>
<td>.00</td>
</tr>
<tr>
<td>GDP per unit of Energy Use</td>
<td>-1.96</td>
<td>0.10</td>
<td>-1.19</td>
<td>-19.51</td>
<td>.00</td>
</tr>
<tr>
<td>Secondary Industry to GDP</td>
<td>0.42</td>
<td>0.14</td>
<td>0.16</td>
<td>3.09</td>
<td>.00</td>
</tr>
<tr>
<td>Foreign Direct Investment</td>
<td>0.09</td>
<td>0.02</td>
<td>0.20</td>
<td>4.06</td>
<td>.00</td>
</tr>
<tr>
<td>International Trade</td>
<td>-0.15</td>
<td>0.06</td>
<td>-0.12</td>
<td>-2.67</td>
<td>.01</td>
</tr>
</tbody>
</table>

F = 92.62  df = 6  p = .00  R² = .86  Adjusted R² = .85.

H₃ᵇ: There is a significant curvilinear explanatory relationship among the percentage change in macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and the percentage change in per capita SO₂ emissions in CEE countries from 1990 to 2002, which is the most recent data available.

A multiple regression analysis was adopted to analyze the influences of percentage changes of each macroeconomic indicator on percentage changes in per capita SO₂ emissions of CEE countries from 1990 to 2002. The number of observations was 87.
The $F$ value (36.91) for the regression model analyzing the five variables was significant ($p = .00$) for an explanatory relationship. The adjusted $R^2$ indicated that the percentage changes in five macroeconomic indicators as a whole explained 71 percent (.71) of the variance in percentage changes in per capita $SO_2$ emissions in CEE countries from 1990 to 2002.

The $t$-statistic, which is the regression coefficient ($B$) divided by the standard error ($SE$), tested the significance of percentage changes in individual predictors on percentage changes in per capita $SO_2$ emissions in CEE from 1990 to 2003. All the percentage changes in five macroeconomic indicators and percentage changes in quadratic GDP per capita in explaining percentage changes in per capita $SO_2$ emissions were significant at .05 significant levels. The $t$-statistics of each predictions were as follows: percentage changes in GDP per capita ($t = 5.65, p = .00$), percentage changes in quadratic GDP per capita ($t = -5.60, p = .00$), percentage changes in GDP per unit of energy use ($t = -2.76, p = .01$), percentage changes in secondary industry to GDP ($t = 6.14, p = .00$), percentage changes in foreign direct investment ($t = 2.26, p = .03$), and percentage changes in international trade ($t = -7.81, p = .00$) from 1990 to 2003.

The order of relative importance, based on the absolute values of the $\beta$ coefficients, of these percentage changes in five macroeconomic indicators and percentage changes in quadratic GDP per capita was percentage changes in GDP per capita ($\beta = 15.25$), followed by percentage changes in quadratic GDP per capita ($\beta = -15.06$), percentage changes in international trade ($\beta = -.52$), percentage changes in secondary industry to GDP ($\beta = .47$), percentage changes in GDP per unit of energy use ($\beta = -.24$), and percentage changes in foreign direct investment ($\beta = .19$).
The regression results showed that (1) the overall regression model was significant \(F=36.91, p = .00\), explaining 71% to 73% of the variation in percentage changes in per capita \(\text{SO}_2\) emissions in CEE from 1990 to 2002; (2) the coefficients of regression analysis showed a positive relationship between percentage change in GDP per capita and percentage changes in per capita \(\text{SO}_2\) emissions and a negative relationship between percentage changes of quadratic GDP per capita and percentage changes in per capita \(\text{SO}_2\) emissions; and (3) the t-statistics (significant of individual predictors) for percentage changes in GDP per capita \((\ln Y)\) and the percentage changes in quadratic GDP per capita \((\ln Y)^2\) were statistically significant at .05 levels. Having met the three conditions, hypothesis 3b was supported.

Table 4-10 presents a summary of the results of the multiple regression analysis of percentage changes in macroeconomic indicators in explaining percentage changes in per capita \(\text{SO}_2\) emissions in CEE from 1990 to 2002.
Table 4-10

**Summary of Multiple Regression Analysis for Percentage Changes in Macroeconomic Indicators Explaining Percentage Changes in Per Capita SO₂ Emissions in CEE Countries from 1990 to 2002 (N = 99)**

<table>
<thead>
<tr>
<th>Variables</th>
<th>B</th>
<th>SE</th>
<th>β</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>-239.195</td>
<td>41.85</td>
<td>-5.72</td>
<td>.00</td>
<td></td>
</tr>
<tr>
<td>GDP per capita</td>
<td>56.45</td>
<td>9.98</td>
<td>15.25</td>
<td>5.65</td>
<td>.00</td>
</tr>
<tr>
<td>Quadratic GDP per capita</td>
<td>-3.31</td>
<td>0.59</td>
<td>-15.06</td>
<td>-5.60</td>
<td>.00</td>
</tr>
<tr>
<td>GDP per unit of Energy Use</td>
<td>-1.18</td>
<td>0.43</td>
<td>-0.24</td>
<td>-2.76</td>
<td>.01</td>
</tr>
<tr>
<td>Secondary Industry to GDP</td>
<td>3.80</td>
<td>0.62</td>
<td>0.47</td>
<td>6.14</td>
<td>.00</td>
</tr>
<tr>
<td>Foreign Direct Investment</td>
<td>0.24</td>
<td>0.11</td>
<td>0.19</td>
<td>2.26</td>
<td>.03</td>
</tr>
<tr>
<td>International Trade</td>
<td>-1.84</td>
<td>0.24</td>
<td>-0.52</td>
<td>-7.81</td>
<td>.00</td>
</tr>
</tbody>
</table>

F = 36.91  df = 6  p = .00  R² = .73  Adjusted R² = .71.

**Research Hypothesis 4**

H₄: There is a significant curvilinear explanatory relationship among the percentage change in macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and the percentage change in per capita emissions (CO₂ and SO₂) of SEA countries from 1990 to 2006, or the most recent data available.

H₄₅: There is a significant curvilinear explanatory relationship among the percentage change in macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and the percentage change in per capita CO₂ emissions in SEA countries from 1990 to 2003, which is the most recent data available.
A multiple regression analysis was adopted to analyze the influences of percentage changes of each macroeconomic indicator on percentage changes in per capita \( \text{CO}_2 \) emissions of SEA countries from 1990 to 2003. The number of observations was 78.

The \( F \) value (1170.54) for the regression model analyzing the five variables was significant \( (p = .00) \) for an explanatory relationship. The adjusted \( R^2 \) indicated that the percentage changes in five macroeconomic indicators as a whole explained 99 percent \( (.99) \) of the variance in percentage changes in per capita \( \text{CO}_2 \) emissions in SEA countries from 1990 to 2003.

All the percentage changes in five macroeconomic indicators and percentage changes in quadratic GDP per capita in explaining percentage changes in per capita \( \text{SO}_2 \) emissions were significant at .05 significant levels. The \( t \)-statistics of each predictions were as follows: percentage changes in GDP per capita \( (t = 5.65, p = .00) \), percentage changes in quadratic GDP per capita \( (t = -5.60, p = .00) \), percentage changes in GDP per unit of energy use \( (t = 2.76, p = .01) \), percentage changes in secondary industry to GDP \( (t = 6.14, p = .00) \), percentage changes in foreign direct investment \( (t = 2.26, p = .03) \), and percentage changes in international trade \( (t = -7.81, p = .00) \) from 1990 to 2003.

The \( t \)-statistic, which is the regression coefficient \( (B) \) divided by the standard error \( (SE) \), tested the significance of percentage changes in individual predictors on percentage changes in per capita \( \text{CO}_2 \) emissions in SEA from 1990 to 2002. The percentage changes in quadratic GDP per capita and all the percentage changes in five macroeconomic indicators, with the exception of percentage changes in foreign direct investment, in explaining percentage changes in \( \text{CO}_2 \) emissions were significant at .05 significant levels. It was apparent that the percentage changes in GDP per capita \( (t = 8.3, \)}
percentage changes in quadratic GDP per capita ($t = -5.90, p = .00$), percentage changes in GDP per unit of energy use ($t = -6.76, p = .00$), percentage changes in secondary industry to GDP ($t = 2.28, p = .03$), and international trade ($t = 2.61, p = .01$) were significant, at the .05 significance level, in explaining percentage changes in per capita CO$_2$ emissions in SEA from 1990 to 2003. Percentage changes in foreign direct investment ($t = .71, p = .48$) was the only variable that was not significant explanatory variable of percentage changes in per capita CO$_2$ emissions of SEA from 1990 to 2003 at a .05 significance level.

The order of relative importance, based on the absolute values of the $\beta$ coefficients, of these macroeconomic predictors was as follows: percentage changes in GDP per capita ($\beta = 2.86$), followed by percentage changes in quadratic GDP per capita ($\beta = -2.07$), percentage changes in GDP per unit of energy use ($\beta = -.19$), percentage changes in international trade ($\beta = .06$), and percentage changes in secondary industry to GDP ($\beta = .06$). The percentage changes in foreign direct investment ($\beta = .02$) was not significant explanatory variable of percentage changes in per capita CO$_2$ emissions in SEA from 1990 to 2003 at a .05 significance level.

The regression results showed that (1) the overall regression model was significant ($F=1170.54, p = .00$), explaining 99% of the variation in percentage changes in per capita CO$_2$ emissions in SEA from 1990 to 2003; (2) the coefficients of regression analysis showed a positive relationship between percentage change in GDP per capita and percentage changes in per capita CO$_2$ emissions and a negative relationship between percentage changes of quadratic GDP per capita and percentage changes in per capita CO$_2$ emissions; and (3) the $t$-statistics (significant of individual predictors) for percentage
changes in GDP per capita ($lnY$) and the percentage changes in quadratic GDP per capita ($lnY)^2$ were statistically significant at .05 levels. Having met the three conditions, hypothesis 4a was supported.

Table 4-11 presents a summary of the results of the multiple regression analysis of percentage changes in macroeconomic indicators in explaining percentage changes in per capita CO$_2$ emissions in SEA from 1990 to 2003.

Table 4-11

| Summary of Multiple Regression Analysis for Percentage Changes in Macroeconomic Indicators in Explaining Percentage Changes in per capita CO$_2$ Emissions in SEA Countries from 1990 to 2003 (N = 78) |
|---|---|---|---|---|---|
| Variables | $B$ | $SE$ | $\beta$ | $t$ | $p$ |
| (Constant) | -12.54 | 0.81 | -15.48 | .00 |
| GDP per capita | 2.46 | 0.30 | 2.86 | 8.33 | .00 |
| Quadratic GDP per capita | -0.11 | 0.02 | -2.07 | -5.90 | .00 |
| GDP per unit of Energy Use | -0.67 | 0.10 | -0.19 | -6.76 | .00 |
| Secondary Industry to GDP | 0.47 | 0.21 | 0.06 | 2.28 | .03 |
| Foreign Direct Investment | 0.01 | 0.02 | 0.02 | 0.71 | .48 |
| International Trade | 0.10 | 0.04 | 0.06 | 2.61 | .01 |

$F = 1170.54 \quad df = 6 \quad p = .00 \quad R^2 = .99 \quad$ Adjusted $R^2 = .99.$

H4b: There is a significant curvilinear explanatory relationship among the percentage change in macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and the percentage change in per capita SO$_2$ emissions in SEA countries from 1990 to 2000, which is the most recent data available.
The multiple regression analysis was adopted to analyze the influences of percentage changes of each macroeconomic indicator on percentage changes in per capita SO$_2$ emissions of SEA countries from 1990 to 2000. The number of observations was 62.

The $F$ value (32.85) for the regression model analyzing the five variables was significant ($p = .00$) for an explanatory relationship. The adjusted $R^2$ indicated that the percentage changes in five macroeconomic indicators as a whole explained 76 percent (.76) of the variance in percentage changes in per capita SO$_2$ emissions of SEA countries from 1990 to 2000.

The $t$-statistic, which is the regression coefficient ($B$) divided by the standard error ($SE$), tested the significance of percentage changes in individual predictors on percentage changes in per capita SO$_2$ emissions in SEA from 1990 to 2000. The percentage change in GDP per capita, percentage changes in international trade and percentage changes in quadratic GDP per capita were significant in explaining percentage change in per capita SO$_2$ emissions. It was appeared that the percentage changes in GDP per capita ($t = 3.06, p = .00$), percentage changes in quadratic GDP per capita ($t = -2.84, p = .01$), and percentage changes in international trade ($t = -5.61, p = .00$). However, percentage changes in GDP per unit of energy use ($t = 0.09, p = .93$), percentage changes in secondary industry to GDP ($t = -1.08, p = .28$), and percentage changes in foreign direct investment ($t = -0.08, p = .94$) were not significant in explaining percentage changes in per capita SO$_2$ emissions in SEA from 1990 to 2000 at a .05 significant level.

The order of relative importance, based on the absolute values of the $\beta$ coefficients, of these macroeconomic predictors was as follows: percentage changes in GDP per capita ($\beta = 5.57$), followed by percentage changes in quadratic GDP per capita ($\beta = -$.
5.26), and percentage changes in international trade ($\beta = -1.02$). Percentage changes in GDP per unit of energy use ($\beta = .01$), percentage changes in secondary industry to GDP ($\beta = -.14$), and percentage changes in foreign direct investment ($\beta = -.08$) failed to explain the percentage changes in per capita SO$_2$ emissions in SEA from 1990 to 2000 at a .05 significance level.

The regression results showed that (1) the overall regression model was significant ($F=32.86, p = .00$), explaining 76% to 78% of the variation in percentage changes in per capita SO$_2$ emissions in SEA from 1990 to 2000; (2) the coefficients of regression analysis showed a positive relationship between percentage changes in GDP per capita and percentage changes in per capita SO$_2$ and a negative relationship between percentage change in quadratic GDP per capita and percentage changes in per capita SO$_2$ emissions; and (3) the $t$-statistics (significant of individual predictors) for percentage changes in GDP per capita ($lnY$) and the percentage changes in quadratic GDP per capita ($lnY)^2$ were statistically significant at .05 levels. Having met the three conditions, hypothesis 4b was supported.

Table 4-12 presents a summary of the results of the multiple regression analysis of percentage changes in macroeconomic indicators in explaining percentage changes in per capita SO$_2$ emissions in SEA from 1990 to 2000.
Table 4-12

Summary of Multiple Regression Analysis for the Percentage Changes in Macroeconomic Indicator in Explaining the Percentage Changes in per capita SO2 Emissions in SEA Countries from 1990 to 2000 (N = 62)

<table>
<thead>
<tr>
<th>Variables</th>
<th>$B$</th>
<th>$SE$</th>
<th>$\beta$</th>
<th>$t$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>-0.79</td>
<td>3.02</td>
<td>-0.26</td>
<td>.80</td>
<td></td>
</tr>
<tr>
<td>GDP per capita</td>
<td>3.45</td>
<td>1.13</td>
<td>5.57</td>
<td>3.06</td>
<td>.00</td>
</tr>
<tr>
<td>Quadratic GDP per capita</td>
<td>-0.20</td>
<td>0.07</td>
<td>-5.26</td>
<td>-2.84</td>
<td>.01</td>
</tr>
<tr>
<td>GDP per unit of Energy Use</td>
<td>0.03</td>
<td>0.37</td>
<td>0.01</td>
<td>0.09</td>
<td>.93</td>
</tr>
<tr>
<td>Secondary Industry to GDP</td>
<td>-0.88</td>
<td>0.81</td>
<td>-0.14</td>
<td>-1.08</td>
<td>.28</td>
</tr>
<tr>
<td>Foreign Direct Investment</td>
<td>0.01</td>
<td>0.09</td>
<td>0.01</td>
<td>0.08</td>
<td>.94</td>
</tr>
<tr>
<td>International Trade</td>
<td>-1.10</td>
<td>0.20</td>
<td>-1.02</td>
<td>-5.61</td>
<td>.00</td>
</tr>
</tbody>
</table>

$F = 32.86 \quad df = 6 \quad p = .00 \quad R^2 = .78 \quad$ Adjusted $R^2 = .76$

Research Hypothesis 5

H5: The percentage change in macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and country categories (transitional countries, CEE, and non-transitional countries, SEA) are significantly explanatory variables of the percentage change in per capita emissions (CO2 and SO2) from 1990 to 2006, or the most recent data available.

H5a: The percentage change in macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and country categories (transitional countries, CEE, and non-transitional countries, SEA) are significant explanatory variables of the percentage change in per capita CO2 emissions from 1990 to 2003, which is the most recent data available.
A multiple regression analysis was adopted to analyze the influences of percentage change of each macroeconomic indicator and country categories (transitional countries, CEE, and non-transitional countries, SEA) on percentage change of per capita CO₂ emissions of CEE and SEA countries from 1990 to 2003. The number of observations was 178.

The $F$ value (313.66) for the regression model analyzing the six variables was significant ($p = .00$) for an explanatory relationship. The adjusted $R^2$ indicated that the percentage changes in five macroeconomic indicators and country categories as a whole explained 93 percent (.93) of the variance in percentage changes in per capita CO₂ emissions from 1990 to 2003.

The $t$-statistic, which is the regression coefficient ($B$) divided by the standard error ($SE$), tested the significance of country categories and percentage changes in individual predictors on percentage changes in per capita CO₂ emissions. The percentage changes in quadratic GDP per capita and all the explanatory variables, with the exception of percentage changes in international trade, in explaining percentage changes in per capita CO₂ emissions at a .05 significance levels. It was apparent that the percentage changes in GDP per capita ($t = 6.29, p = .00$), percentage changes in quadratic GDP per capita ($t = -4.68, p = .00$), percentage changes in GDP per unit of energy use ($t = -15.41, p = .00$), percentage changes in secondary industry to GDP ($t = 4.27, p = .00$), percentage changes in foreign direct investment ($t = 3.89, p = .00$), and country categories ($t = 2.08, p = .04$). However, percentage changes in international trade ($t = -0.74, p = .46$) was not significant in explaining percentage changes in per capita CO₂ emissions in SEA from 1990 to 2000 at a .05 significant level.
Based on the absolute values of the $\beta$ coefficients, the order of relative importance of these macroeconomic predictors and country categories was as follows: percentage changes in GDP per capita ($\beta = 2.58$), followed by percentage changes in quadratic GDP per capita ($\beta = -1.91$), percentage changes in GDP per unit of energy use ($\beta = -0.40$), percentage changes in secondary industry to GDP ($\beta = 0.12$), percentage changes in foreign direct investment ($\beta = 0.11$), and country categories ($\beta = 0.07$).

The regression results showed that (1) the overall regression model was significant ($F = 313.66, p = .00$), explaining 92% to 93% of the variation in percentage changes in per capita CO$_2$ emissions from 1990 to 2003 in CEE and SEA regions; (2) the coefficients of regression analysis showed a statistical significant, at .05 significance levels, and positive relationship between country categories, CEE or transitional countries, and percentage changes in per capita CO$_2$ emissions from 1990 to 2003 in CEE and SEA regions. Having met the two conditions, hypothesis 5a was supported.

Table 4-13 presents a summary of the results of the multiple regression analysis of country categories and percentage changes in macroeconomic indicators in explaining percentage changes in per capita CO$_2$ emissions from 1990 to 2003.
Summary of Multiple Regression Analysis for Country Categories and the Percentage Changes in Macroeconomic Indicators in Explaining the Percentage changes in per capita CO₂ Emissions from 1990 to 2003 (N = 178)

<table>
<thead>
<tr>
<th>Variables</th>
<th>B</th>
<th>SE</th>
<th>β</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>-11.84</td>
<td>1.60</td>
<td>-7.42</td>
<td>.00</td>
<td></td>
</tr>
<tr>
<td>GDP per capita</td>
<td>2.51</td>
<td>0.40</td>
<td>2.58</td>
<td>6.29</td>
<td>.00</td>
</tr>
<tr>
<td>Quadratic GDP per capita</td>
<td>-0.11</td>
<td>0.02</td>
<td>-1.91</td>
<td>4.68</td>
<td>.00</td>
</tr>
<tr>
<td>GDP per unit of Energy Use</td>
<td>-1.04</td>
<td>0.07</td>
<td>-0.40</td>
<td>-15.41</td>
<td>.00</td>
</tr>
<tr>
<td>Secondary Industry to GDP</td>
<td>0.56</td>
<td>0.13</td>
<td>0.12</td>
<td>4.27</td>
<td>.00</td>
</tr>
<tr>
<td>Foreign Direct Investment</td>
<td>0.08</td>
<td>0.02</td>
<td>0.11</td>
<td>3.89</td>
<td>.00</td>
</tr>
<tr>
<td>International Trade</td>
<td>-0.03</td>
<td>0.05</td>
<td>-0.02</td>
<td>-0.74</td>
<td>.46</td>
</tr>
<tr>
<td>CEE country</td>
<td>0.12</td>
<td>0.06</td>
<td>0.07</td>
<td>2.08</td>
<td>.04</td>
</tr>
</tbody>
</table>

Note. $F = 313.66\quad df = 7\quad p = .00\quad R^2 = .93\quad$ Adjusted $R^2 = .92$

H5b. The percentage change of macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and country categories (transitional countries, CEE, and non-transitional countries, SEA) are significant explanatory variables of the percentage change in per capita SO₂ emissions from 1990 to 2000, which is the most recent data available.

A multiple regression analysis was adopted to analyze the influences of country categories and percentage changes in macroeconomic indicators on percentage changes in per capita SO₂ emissions of CEE and SEA countries from 1990 to 2000. The number of observations was 150.
The $F$ value (30.35) for the regression model analyzing the six variables was significant ($p = .00$) for an explanatory relationship. The adjusted $R^2$ indicated that the percentage changes in five macroeconomic indicators and country categories (transitional countries, CEE, and non-transitional countries, SEA) as a whole explained 58 percent (.58) of the variance in percentage changes in per capita SO$_2$ emissions of CEE and SEA countries from 1990 to 2000.

The $t$-statistic, which is the regression coefficient ($B$) divided by the standard error ($SE$), tested the significance of country categories and percentage changes in individual predictors on percentage changes in per capita SO$_2$ emissions. The percentage changes in secondary industry to GDP ($t = 6.24, p = .00$), percentage changes in foreign direct investment ($t = 4.34, p = .00$), percentage changes in international trade ($t = -9.53, p = .00$), and country categories ($t = -2.95, p = .00$) were significant in explaining percentage changes in per capita SO$_2$ emissions for the 1990 to 2000 timeframe at a .05 significance level. However, percentage changes in GDP per capita ($t = .75, p = .45$), percentage changes in quadratic GDP per capita ($t = -.57, p = .00$) and percentage changes in GDP per unit of energy use ($t = .06, p = .95$) were not significant in explaining percentage changes in per capita SO$_2$ emissions for 1990 to 2000 timeframe at a .05 significance level.

The order of relative importance, based on the absolute values of the $\beta$ coefficients, was as follows: percentage changes in international trade ($\beta = -.76$), followed by percentage changes in secondary industry to GDP ($\beta = .43$), percentage changes in foreign direct investment ($\beta = .31$) and country categories ($\beta = -.27$).
The regression results showed that (1) the overall regression model was significant ($F = 30.35, p = .00$), explaining 58% to 60% of the variation in percentage changes in per capita SO$_2$ emissions from 1990 to 2000 in CEE and SEA regions; (2) the coefficients of regression analysis show a statistical significant, at .05 significance levels, and negative relationship between of country categories, CEE or transitional countries, and percentage changes in per capita SO$_2$ emissions from 1990 to 2000 in CEE and SEA regions. Having met the two conditions, hypothesis 5b was supported.

Table 4-14 presents a summary of the results of the multiple regression analysis of country categories and percentage changes in macroeconomic indicators in explaining percentage changes in per capita SO$_2$ emissions for 1990 to 2000 timeframe.

Table 4-14

<table>
<thead>
<tr>
<th>Variables</th>
<th>$B$</th>
<th>$SE$</th>
<th>$\beta$</th>
<th>$t$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>-4.01</td>
<td>6.11</td>
<td>-0.66</td>
<td>.51</td>
<td></td>
</tr>
<tr>
<td>GDP per capita</td>
<td>1.14</td>
<td>1.53</td>
<td>0.79</td>
<td>0.75</td>
<td>.45</td>
</tr>
<tr>
<td>Quadratic GDP per capita</td>
<td>-0.05</td>
<td>0.09</td>
<td>-0.59</td>
<td>-0.57</td>
<td>.57</td>
</tr>
<tr>
<td>GDP per unit of Energy Use</td>
<td>0.02</td>
<td>0.25</td>
<td>0.01</td>
<td>0.06</td>
<td>.95</td>
</tr>
<tr>
<td>Secondary Industry to GDP</td>
<td>3.17</td>
<td>0.51</td>
<td>0.43</td>
<td>6.24</td>
<td>.00</td>
</tr>
<tr>
<td>Foreign Direct Investment</td>
<td>0.33</td>
<td>0.08</td>
<td>0.31</td>
<td>4.34</td>
<td>.00</td>
</tr>
<tr>
<td>International Trade</td>
<td>-1.71</td>
<td>0.18</td>
<td>-0.76</td>
<td>-9.53</td>
<td>.00</td>
</tr>
<tr>
<td>CEE country</td>
<td>-0.63</td>
<td>0.21</td>
<td>-0.27</td>
<td>2.95</td>
<td>.00</td>
</tr>
</tbody>
</table>

Note. $F = 30.35$  $df = 7$  $p = .00$  $R^2 = .60$  Adjusted $R^2 = .58$. 

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**Research Hypothesis 6**

H6: There are significantly fewer capita emissions (CO₂ and SO₂) in CEE (i.e., transitional countries) than that in SEA (i.e., non-transitional countries) demonstrated in data from 1990 to 2006, or the most recent data available.

H6ₐ: There is significantly fewer per capita CO₂ emission in CEE (i.e., transitional countries) than in SEA (i.e., non-transitional countries) from 1990 to 2003, which is most recent data available.

An independent t-test was applied to analyze the difference in per capita CO₂ emissions according to country categories. The numbers of observations were 112 in CEE and 84 in SEA. The means of per capita CO₂ emissions in CEE and SEA were 8.32 and 2.57 per capita tons, respectively. The F-statistic (65.31) for testing equality of variances was significant ($p = .00$) at the .05 significance level resulting in use of the adjusted t-value. The t-value (5.36) was significantly higher ($p = .00$) for CEE in per capita CO₂ emissions compared with SEA. Hypothesis 6ₐ, that there is significantly less per capita CO₂ emission in CEE than in SEA from 1990 to 2003, was not supported at the .05 significance level, and an opposite significant relationship was revealed. Table 4-15 shows the summary of results of the independent t-test of per capita CO₂ emissions in CEE and SEA for the 1990 to 2003 timeframe.
H6b: There is significantly fewer per capita SO₂ emission in CEE (i.e., transitional countries) than in SEA (i.e., non-transitional countries) from 1990 to 2000, which is the most recent data available.

An independent t-test was applied to analyze the difference in per capita SO₂ emissions according to country categories. The numbers of observation were 100 in CEE and 66 in SEA. The means of per capita SO₂ emissions in CEE and SEA were 747.76 kg and 396.51 kg per capita, respectively. The F-statistic (24.13) for testing equality of variances was significant ($p = .00$) resulting in use of the adjusted t-value. The t-value (2.07) was significantly higher ($p = .00$) for CEE in per capita CO₂ emissions in CEE compared with SEA. Hypothesis 6b, that there is significantly less per capita CO₂ emission in CEE than in SEA from 1990 to 2000, was not supported at the .05 significance levels, and an opposite significant relationship resulted. As shown in Table
4-15, the results of the independent t-test of per capita SO₂ emissions in CEE and SEA for the 1990 to 2000 timeframe are summarized.

**Summary of Chapter IV**

Chapter IV presented the results of the investigation according to epistemological views and fundamental approaches that underlie country backgrounds and macroeconomic indicators of environmental deterioration in CEE and SEA. Of 10 regression analyses, results showed that nine sub hypotheses were supported, and hypothesis 2b was only partially supported. The overall testing of each explanatory model was significant, with the F-values ranged from 19.55 to 1170.54. The power of macroeconomic indicators and country category variables to predict changes in air emissions indicators was very good; adjusted $R^2$ for each regression ranged from 58 percent to 99 percent.

There were three conditions necessary to support hypotheses 1 to 4: (1) the $F$ statistic must be significant ($p \leq .05$), which is a test of the overall regression model; (2) the sign of $Y$ (or $\ln Y$) term and the sign of $Y^2$ (or $(\ln Y)^2$) in the regression models must be positive and negative respectively, and (3) the $Y$, $\ln Y$, $Y^2$, and $(\ln Y)^2$ must have significant $t$-statistics ($p \leq .05$). In order to support hypothesis 5, two conditions were required: (1) the $F$ statistic must be significant ($p < .05$), which is a test of the overall regression model; (2) country category must have a significant $t$-statistic ($p < .05$). Two conditions were required to supported hypothesis 6: (1) the $F$ statistic must be significant ($p \leq .05$), which is a test of the overall regression model; (2) country category must have a significant $t$-statistic ($p \leq .05$).
The coefficients signs of per capita GDP, quadratic per capita per GDP, percentage changes in per capita GDP, and percentage changes in quadratic per capita GDP were as expected in all regression analyses. That is, income at first increases emissions pressure and then reduces it after income reaches a certain level. However, when testing for significant of the curvilinear relationship between income and emission in the CEE and SEA regions, the results showed that all sub hypotheses were significant except one—the curvilinear relationship between GDP per capita and per capita SO₂ emission in SEA countries was not significant at a .05 significance level.

The country category was significant, in explaining the percentage changes in per capita emissions in this study. In other words, the country category—transition—did affect the percentage changes in CO₂ and SO₂. However, the signs of the coefficient of country category—direction of a CEE country’s impact on emissions—were differed between emissions. The CEE country category affected percentage change in per capita CO₂ positively but it affected the percentage change in per capita SO₂ negatively. Moreover, when tested the difference of environmental emissions between CEE and SEA country in hypothesis 6, the results showed that the both CO₂ and SO₂ per capita emissions in CEE were significant more than that of in SEA countries from 1990 to 2000 or 2003, depended on emissions, timeframe.

The effects of GDP per unit of energy use, secondary industry to GDP, foreign direct investment, international trade, and their percentage change on atmospheric concentrations can be verified in emissions and economic backgrounds. The next chapter, Chapter V, discusses the findings in terms of interpretations, implications, limitations, conclusions, and recommendations regarding this investigation.
CHAPTER V
DISCUSSION

The study was the first to investigate and examine the relationship among the economic background, economic growth, and environmental deterioration. The specific purpose of this non-experimental, quantitative, correlational (explanatory), and causal-comparative research of environmental deterioration in CEE and SEA countries were (1) to describe the macroeconomic indicators and environmental pollution in CEE and SEA countries; (2) to explore the relationship between macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and environmental pollution measures of per capita emissions (CO₂ and SO₂) of all CEE and SEA countries; (3) to examine the curvilinear explanatory relationship between economic growth and environmental deterioration in CEE and SEA regions; and (4) to compare environmental emissions in two regions with comparable income per capita but different in economic backgrounds, transitional CEE and non-transitional SEA countries.

In this study, two groups of explanatory factors were analyzed for their affect on environmental emissions: (1) independent variables of macroeconomic indicators, and (2) attribute variables of country category. Independent variables measured by five macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade). Country category involved transitional CEE and non-transitional SEA countries.

All of the data for analysis sourced from the World Development Indicators, published by The World Bank (2007); the exception was sulphur dioxin emissions, this
came from (2005c). A total of three research questions and six hypotheses with 12 sub-
sub-hypotheses were developed. Macroeconomic indicators by country category with
between 66 to 178 samples were used to answer and test research questions and
hypotheses in this investigation.

Findings of this study indicated that differing economic backgrounds undermined
environmental quality in CEE and SEA. Transitional economies, CEE, showed an
increasing pressure on CO₂ emissions but a decreasing pressure on SO₂ emissions.
However, regarding the inverted-U curvilinear relationship between GDP per capita and
per capita emissions, this investigation showed different results according to the regions.
In the CEE region, there were significant explanatory inverted-U curvilinear relationship
between GDP per capita and per capita emissions, both CO₂ and SO₂, and percentage
changes in GDP per capita and percentage changes in per capita emissions, both CO₂ and
SO₂. However, in SEA region, the regression analysis showed different results. The
inverted-U curvilinear relationship between GDP per capita and per capita CO₂ was
supported, but the inverted-U curvilinear relationship between GDP per capita and per
per capita SO₂ was partially supported. Nevertheless, the curvilinear relationships between
percentage changes in GDP per capita and percentage changes in emissions, both CO₂
and SO₂, in SEA were supported. This chapter presents a discussion of the results
reported in Chapter IV.

Interpretations

Descriptive Characteristics of the Sample

Research has shown that economic expansion, legislation, urbanization, technology
improvements, and the openness of a country have significant effects on environmental
quality (Barguin, 2006; Dasgupta et al., 2002; Iwami, 2004, 2005; Panayotou, 2000). This study adopted five macroeconomic economic indicators, GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade, to investigate environmental deterioration and atmospheric emissions in countries with different economic backgrounds.

The trends of per capita CO$_2$ and SO$_2$ emissions in CEE and SEA have differed in the period from 1990 to 2006, the most recent data available. Per capita CO$_2$ emissions dropped 2.04 percent per year in CEE but increased 5.06 percent annually in SEA from 1990 to 2003. Per capita SO$_2$ emissions decreased by 10.18 percent in CEE annually but were increased by 0.43 percent per year in SEA for the research timeframe. Over the same time period, GDP per capita was growing in these two regions. The average GDP per capita, or economic growth rate, grew 1.96 and 3.45 percent annually in CEE and SEA, respectively, from 1990 to 2005.

GDP per unit of energy used increased by 3.76 and 0.42 percent per year in CEE and SEA, respectively from 1990 to 2005 research timeframe. This result implied that both regions have consumed their energy more efficiently from 1990 to 2005. However, the contributions of secondary industry to GDP were quite different between these two regions. Secondary industry to GDP was decreased by 2.23 percent per year in CEE but increased by 0.59 percent per year in SEA. From a global point of view, foreign direct investment to GDP increased remarkably in both regions. It grew 45.57 and 11.39 percent per year in CEE and SEA, respectively, from 1990 to 2005. International trade to GDP grew 5.74 and 4.60 percent annually in CEE and SEA, respectively, for the 1990 to 2005 timeframe. These findings were consistent with most previous studies in these
areas (Archibald et al., 2004; Benacek, 2000; Botcheva-Andonova et al., 2006; Iwami, 2005).

**Inferential Hypotheses Testing**

Multiple regression analysis was utilized to test hypotheses 1 to 5 and their sub-hypotheses in this study. There are two functions of multiple regression analysis: to summarize data and to examine significant trends. The F-value, $R^2$, and $t$-statistics are major inferential statistics of the regression model. The F-value and its significance level are recognized as the overall significance of the regression model. $R^2$ is the proportion of variance of the dependent variable that can be explained by independent variables. $t$-statistics and its proportion examine the significance of each independent variable.

To support hypotheses 1 to 4, three conditions were necessary: (1) the F statistic must be significant ($p \leq .05$); (2) the sign of $Y$ (or $lnY$) term and the sign of $Y^2$ (or $(lnY)^2$) in the regression models must be positive and negative respectively, and (3) the $Y$, $lnY$, $Y^2$, and $(lnY)^2$ must have significant $t$-statistics ($p < .05$). In order to support hypothesis 5, two conditions were required: (1) the F statistic must be significant ($p \leq .05$); and (2) country category must have a significant $t$-statistic ($p \leq .05$).

The regression results of hypotheses 1 to 4 showed that the coefficients signs of per capita GDP, quadratic per capita per GDP, percentage changes in per capita GDP, and percentage changes in quadratic per capita GDP were as expected in all regression analyses. That is, income at first increases emissions pressure and then reduces it after income reaches a certain level. However, when testing for significance of the curvilinear relationship between income and emission in the CEE and SEA regions, the results showed that all sub hypotheses were significant except one —the curvilinear relationship
between GDP per capita and per capita SO$_2$ emission in SEA countries was not significant at a .05 significance level.

The country category was significant, in explaining the percentage changes in per capita emissions in this study. In other words, the country category—transition—did affect the percentage changes in CO$_2$ and SO$_2$. However, the signs of the coefficient of country category—direction of a CEE country’s impact on emissions—were differed between emissions. The CEE country category affected percentage change in per capita CO$_2$ positively but it affected the percentage change in per capita SO$_2$ negatively.

The independent $t$-tests was utilized to test hypothesis 6 and its sub-hypotheses for showing whether the means of two groups were significantly different from each other. The results of independent $t$-tests in hypothesis 6 showed that the both CO$_2$ and SO$_2$ per capita emissions in CEE were significant more then that of in SEA countries from 1990 to 2000 or 2003, depended on emissions.

**GDP Per Capita in Explaining Emissions of Per Capita CO$_2$ and Per Capita SO$_2$**

**Per capita CO$_2$.**

Based on the results of the regression equations sampled, the findings indicated that GDP per capita was a significant positive explanatory variable of per capita CO$_2$ emissions in both CEE and SEA countries. In other words, per capita CO$_2$ emissions increased in line with GDP per capita expansions in these two regions. This result conformed to most research regarding the EKC hypothesis in CEE (Bruvoll & Medin, 2003; Kukla-Gryz & Zylicz, 2004; Panayotou, 2000).

**Per capita SO$_2$.** According to the results of regression analysis, the findings showed that GDP per capita was a significant positive explanatory variable of per capita
SO₂ emissions in both CEE and SEA countries. That is, as per capita income increased the result was an increase in per capita SO₂ emissions in both CEE and SEA. In other words, per capita SO₂ emissions increased along with GDP per capita in these two regions, ceteris paribus. These results were consistent with the findings of Iwami (2004, 2005).

*Quadratic GDP Per Capita in Explaining Emissions of Per Capita CO₂ and Per Capita SO₂*

**Per capita CO₂.** Quadratic GDP per capita was a significantly inversely related explanatory variable in explaining per capita CO₂ emissions in CEE and SEA. That is, after per capita incomes reached a certain level, an increase in income resulted in a decrease in per capita CO₂ emissions in both CEE and SEA regions. This result was consistent with Dasgupta et al. (2002) and Iwami (2004) but contradictory to Kukla-Gryz and Zylicz (2004).

**Per capita SO₂.** Quadratic GDP per capita was a significant inversely related explanatory variable in explaining per capita SO₂ emissions in CEE region. That is, after per capita incomes reached to a certain level, an increase in income resulted in a decrease in per capita SO₂ emissions in the CEE region. This result was consistent with Iwami (2004) and Liang (2006).

However, according to regression analysis model, quadratic GDP per capita ($t = -1.15, p = .26$) was not a significant variable (at .05 significance levels) in explaining an inverse relationship with per capita SO₂ emissions in SEA region from 1990 to 2000. Since the sample size of regression analysis of GDP per capita on per capita SO₂ emissions in SEA only involved 66 observations, which was far less than a sufficient
minimum sample size required, 90 observations, in this regression analysis, therefore, estimate errors were unavoidable. Moreover, the overall regression model only explaining 63% to 67% of the variation in per capita SO₂ emissions in SEA from 1990 to 2000, therefore, more explanatory variables were suggested to enhance the R². This result of this analysis was consistent with Kukla-Gryz and Zylicz (2004) but contradictory to Iwami (2004) and Liang (2006).

In summary, according to the EKC hypothesis, a negative and significant coefficient of quadratic GDP per capita is one of the necessary and sufficient conditions to explain the inverted-U curvilinear relationship between income and emissions. The results of regression analyses in this study have shown that the curvilinear relationship between GDP per capita and per capita emissions (both CO₂ and per capita SO₂) in CEE countries cannot be rejected. The regression results also indicated that there was a curvilinear relationship between GDP per capita and per capita CO₂ emission in SEA from 1990 to 2003. However, the hypothesis of an inverted-U curvilinear relationship between per capita GDP and per capita SO₂ in SEA from 1990 to 2000 was partially supported because the coefficient of quadratic per capita GDP was not statistically significant at .05 significance levels.

**GDP Per Unit of Energy Use in Explaining Emissions of Per Capita CO₂ and Per Capita SO₂**

*Per capita CO₂.* GDP per unit of energy use was a significant inversely related explanatory variable in explaining per capita CO₂ in CEE and SEA. That is, an increase in GDP per unit of energy use resulted in a decrease in per capita CO₂ in CEE and SEA from 1990 to 2003. The negative sign of estimated coefficients of GDP per unit of
energy was as expected, because a higher GDP per unit of energy use leaded to lower per capita emissions. The minus sign of estimated coefficients of GDP per unit of energy use in the regression models tested conformed to Bruvoll and Medin (2003) and Iwami (2004, 2005).

*Per capita SO₂.* According to the regression equations tested, the regression coefficients of GDP per unit of energy use were accompanied by minus signs and showed statistical significance as expected in both CEE and SEA regions. In other words, GDP per unit of energy use was a significant inversely related explanatory variable in explaining per capita SO₂ in CEE and SEA. That is, the higher energy efficiency (or GDP per unit of energy use), the lower per capita SO₂ emissions in both CEE and SEA regions. The results were consistent with Bruvoll and Medin (2003) and Iwami (2005).

**Secondary Industry to GDP in Explaining Emissions of Per Capita CO₂ and Per Capita SO₂**

*Per capita CO₂.* Based on the regression results, the secondary industry to GDP was not a significant variable in explaining per capita CO₂ in either CEE or SEA. That is, a statistical significant relationship between secondary industry to GDP and per capita CO₂ emission in either CEE or SEA from 1990 to 2003 was rejected. The findings supported Iwami's (2005) results and were in contradiction to Bruvoll and Medin (2003) and Dasgupta et al. (2002).

*Per capita SO₂.* The effects of secondary industry to GDP on per capita SO₂ were different between the CEE and SEA regions. Secondary industry to GDP was a significant positive explanatory variable in CEE but it was not significant in SEA. That is, an increase in secondary industry to GDP resulted in an increase in per capita SO₂.
emissions in the CEE region only. The positive explanatory relationship between secondary industry to GDP and per capita $\text{SO}_2$ in CEE was consistent with Bruvoll and Medin (2003) and Dasgupta et al., (2002), and partly supported Iwami’s findings (2005), but did not support Liang (2006).

**Foreign Direct Investment in Explaining Emissions of Per Capita $\text{CO}_2$ and Per Capita $\text{SO}_2$**

**Per capita $\text{CO}_2$**. The effects of foreign direct investment on per capita $\text{CO}_2$ were different between the CEE and SEA regions. Foreign direct investment was a significant positive explanatory variable in CEE but it was not significant in SEA. In other words, an increase in foreign direct investment resulted in an increase in per capita $\text{CO}_2$ emissions in the CEE region only. However, this relationship cannot be found in the SEA region. The positive explanatory relationship between foreign direct investment and per capita $\text{CO}_2$ emissions in CEE was consistent with Bruvoll and Medin (2003) and Dasgupta et al. (2002).

**Per capita $\text{SO}_2$**. The regression results in this study showed that foreign direct investment was not a statistical significant explanatory in explaining per capita $\text{SO}_2$ emissions in either CEE or SEA regions. Moreover, the regression coefficients signs, direction of impact of foreign direct investment, on per capita $\text{SO}_2$ emissions were different between CEE and SEA. The signs of coefficients of foreign direct investment on per capita $\text{SO}_2$ were positive in CEE and negative in SEA respectively. However, the regression result with a minus coefficient of foreign direct investment, that is the SEA countries, was consistent with the studies of Cernat (2002) and Liang (2006).
International Trade in Explaining Emissions of Per Capita CO₂ and Per Capita SO₂

Per capita CO₂. The effects of international trade on per capita CO₂ were different between CEE and SEA. It was a significant positive explanatory variable in SEA but was negative and not significant in CEE. That is, an increase in international trade in SEA resulted in an increase in per capita CO₂ emissions. However, this relationship between international trade and per capita CO₂ emissions cannot be applied in the CEE region. The result of a positive and significant effect of international trade on per capita CO₂ in SEA was consistent with Radej and Zakotnik (2003).

Per capita SO₂. The effect of international trade on per capita SO₂ was a significant inversely related explanatory variable in explaining per capita SO₂ emissions in both CEE and SEA regions. That is, an increase in international trade resulted in a decrease in per capita SO₂ emissions in CEE and SEA regions. This result was in contradiction to Liang (2006).

Percentage Changes in GDP Per Capita in Explaining Percentage Changes in Emissions of Per Capita CO₂ and Per Capita SO₂

Percentage changes in per capita CO₂. Based on the results of the regression equations tested, the findings indicated that the percentage changes in GDP per capita was a significant positive explanatory variable of the percentage change in per capita CO₂ emissions in both CEE and SEA countries. In other words, an increase in percentage changes in per capita GDP resulted in an increase in percentage changes in per capita CO₂ emissions in both CEE and SEA regions. This result conformed to most research regarding to the EKC hypothesis in CEE (Bruvoll & Medin, 2003; Iwami, 2004, 2005; Kahn, 2002; Kukla-Gryz & Zylicz, 2004).
Percentage changes in per capita SO$_2$. Based on the results of regression models tested, the findings indicated that the percentage change in GDP per capita was a significant positive explanatory variable of the percentage changes in per capita SO$_2$ emissions in CEE and SEA regions. That is, an increase in the percentage changes in GDP per capita resulted in an increase in a percentage changes in per capita SO$_2$ emissions in both CEE and SEA regions. These results were consistent with the findings of Kahn (2002), Liang (2006), and Iwami (2004, 2005).

**Percentage Changes in Quadratic GDP Per Capita in Explaining Percentage Changes in Emissions of Per Capita CO$_2$ and Per Capita SO$_2$**

**Percentage changes in per capita CO$_2$.** A percentage change in quadratic GDP per capita was a significant inversely related explanatory variable in explaining a percentage change in per capita CO$_2$ emissions in both CEE and SEA. In other words, an increase in percentage changes in quadratic GDP per capita resulted in a decrease in percentage changes in per capita CO$_2$ emissions in both CEE and SEA. This result was consistent with Iwami (2004) but contradictory to Kukla-Gryz and Zylicz (2004).

**Percentage changes in per capita SO$_2$.** A percentage change in quadratic GDP per capita was a significant inversely related explanatory variable in explaining a percentage change in per capita SO$_2$ emissions in both CEE and SEA regions. That is, an increase in percentage changes in quadratic GDP per capita resulted in a decrease in percentage changes in per capita CO$_2$ emissions in both CEE and SEA. These results were contradictory to Kukla-Gryz and Zylicz (2004) but consistent with other previous investigations (Bruvoll & Medin, 2003; Dasgupta et al., 2002; Kahn, 2002).
According to the regression results on linear and quadratic percentage changes in GDP per capita, the hypotheses of inverted-U curvilinear relationship between percentage changes in GDP and percentage changes in emissions (both CO$_2$ and SO$_2$) were supported in both CEE and SEA regions.

**Percentage Changes in GDP Per Unit of Energy Use in Explaining Percentage Changes in Emissions of Per Capita CO$_2$ and Per Capita SO$_2$**

**Percentage change in per capita CO$_2$.** A percentage change in GDP per unit of energy use was a significant inversely explanatory in explaining a percentage change in per capita CO$_2$ in CEE and SEA. That is, an increase in percentage change of GDP per unit of energy use resulted in a decrease in percentage change in per capita CO$_2$ emission in CEE and SEA. These regression results conformed to Bruvoll and Medin (2003) and Iwami (2004, 2005).

**Percentage change in per capita SO$_2$.** A percentage change in GDP per unit of energy use was an inversely related explanatory in explaining percentage change in per capita SO$_2$. That is, an increase in percentage changes in GDP per unit of energy use resulted in a decrease in percentage changes in per capita SO$_2$ in both CEE and SEA regions in this study. The results were consistent with Bruvoll and Medin (2003), Liang (2006), and Iwami (2005).

**Percentage Changes in Secondary Industry to GDP in Explaining Percentage Changes in Emissions of Per Capita CO$_2$ and Per Capita SO$_2$**

**Percentage change in per capita CO$_2$.** Based on the regression models tested, a percentage change in secondary industry to GDP was a significant positive explanatory variable of a percentage change in per capita CO$_2$ in both CEE and SEA. In other words,
an increase in percentage changes in secondary industry to GDP resulted in an increase in percentage changes in per capita CO$_2$ in both CEE and SEA regions in this study. The findings were consistent with Bruvoll and Medim (2003), Dasgupta et al. (2002) and Iwami (2004).

Per capita SO$_2$. Based on the regression models tested a percentage change in secondary industry to GDP were a significant positive explanatory variable on a percentage change in per capita SO$_2$ in both CEE and SEA regions. In other words, an increase in percentage changes in secondary industry to GDP resulted in an increase in percentage changes in per capita SO$_2$ in both CEE and SEA countries. These results were consistent with Bruvoll and Medin (2003) and Dasgupta et al., (2002), partly confirmed with Iwami (2005), and in contradistinction to Liang (2006).

Percentage Changes in Foreign Direct Investment in Explaining Percentage Changes in Emissions of Per Capita CO$_2$ and Per Capita SO$_2$

Percentage changes in per capita CO$_2$. The regression results of a percentage change in foreign direct investment on a percentage change in per capita CO$_2$ were different between CEE and SEA. The percentage change in foreign direct investment was a significant positive explanatory variable of percentage change in per capita CO$_2$ in CEE but was not significant in explaining percentage changes in per capita CO$_2$ emissions in SEA. In other words, an increase in percentage changes in foreign direct investment to GDP resulted in an increase in percentage changes in per capita CO$_2$ emissions in CEE countries only. The result of a significant positive explanatory relationship between percentage changes in foreign direct investment and percentage
changes in per capita CO₂ in this study was inconsistent with Bruvoll and Medin (2003) and Dasgupta et al (2004).

**Percentage changes in per capita SO₂.** Regarding a percentage changes in foreign direct investment in explaining percentage changes in per capita SO₂, the results showed it was a significant positive explanatory variable in CEE countries but was not statistically significant in SEA countries. In other words, an increase in percentage changes in foreign direct investment to GDP resulted in an increasing in percentage changes in per capita SO₂ emissions in CEE countries only. The result of a significant positive explanatory relationship between percentage changes in foreign direct investment and percentage changes in per capita SO₂ in CEE was inconsistent with Cernat (2002) and Liang (2006).

**Percentage Changes in International Trade in Explaining Percentage Changes in Emissions of Per Capita CO₂ and Per Capita SO₂**

**Percentage changes in per capita CO₂.** The effects of a percentage change in international trade on a percentage change in per capita CO₂ were different between CEE and SEA regions. A percentage change in international trade was a negatively significant explanatory variable in explaining percentage change in per capita CO₂ emissions in CEE but was a positively significant explanatory variable in SEA region. In other words, an increase in the percentage changes in trade led to a decrease in the percentage change in per capita CO₂ in CEE (decreasing environmental pressures) but an increase in a percentage change in per capita CO₂ in SEA (increasing environmental pressures). The results according to regressions equations tested in CEE were partly consistent with
Radej and Zakotnik (2003). The regression results in SEA were consistent with Radej and Zakotnik (2003).

**Percentage changes in per capita SO₂.** The regressions results of this study showed that a percentage change in international trade was a significant positive explanatory variable in a percentage change in per capita SO₂ in CEE countries only. A percentage change in international trade was not statistically significant in explaining percentage changes in per capita SO₂ in SEA. In other words, an increase in the percentage changes in trade resulted in a decrease in the percentage change in per capita SO₂ in CEE. This finding was inconsistent with Cernat (2002) and Liang (2005).

**Country Category in Explaining Percentage Changes in Per Capita CO₂ and Per capita SO₂**

**Percentage changes in Per Capita CO₂.** No previous research has explored the effects of different country categories on environmental deterioration. In this investigation, countries were measured by economic background—transitional CEE and non-transitional SEA countries. The results of the regression model showed a significant and positive relationship between the CEE, or transition country, and percentage change in CO₂ per capita emission. In other words, the findings indicated that CEE’s economic background was a significant positive explanatory variable (increasing pressures) variable in affecting percentage changes in per capita CO₂ emissions from 1990 to 2003.

**Percentage changes in Per Capita SO₂.** This investigation was the first study to hypothesize that the country category is a mediator variable for environmental deterioration. Country category was measured by economic backgrounds—transitional CEE and non-transition SEA in this study. The regression results showed a significant
and negative relationship between CEE, or transitional economies, and percentage change in per capita SO₂ emission. In other words, the findings indicated that CEE’s economic background was a significant inversely explanatory (decreasing pressure) variable in affecting percentage changes in per capita SO₂ emission from 1990 to 2000.

To summarize, this analysis utilized available data of CEE and SEA countries to provide some important information regarding the relationship among economic background, economic growth, and environmental deterioration from 1990 to 2006, the most recent data available. The questions implicit in this analysis were:

1. Would it be possible to find an inverted-U curvilinear relationship between per capita income and per capita emissions in CEE and SEA? The study showed an inverted-U curvilinear relationship between GDP per capita and per capita emissions (both CO₂ and SO₂) in CEE countries. However, in SEA countries, this inverted-U curvilinear relationship hypotheses was supported between per capita GDP and per capita CO₂ but was partially supported between per capita GDP and per capita SO₂.

2. Would it be possible to find an inverted-U curvilinear relationship between percentage changes in per capita GDP and percentage changes in per capita emissions in CEE and SEA? The answers are yes for both emissions (CO₂ and SO₂) and both regions according to the data and models of this study.

3. Would country background affect the environmental quality? The answer is yes according to the data. The results of the regression model tested suggested CEE’s economic background was a significant positive explanatory variable of percentage changes in per capita CO₂ from 1990 to 2003. On the other hand, the CEE’s
economic background of transition economies was a significant inversely explanatory variable in explaining percentage changes in per capita SO\(_2\). In other words, CEE showed a positive effect (increasing environmental pressures) on percentage changes in per capita CO\(_2\) but a negative effect (decreasing environmental pressures) on percentage changes in per capita SO\(_2\) per capita. Given this analysis, the question is why country background has different effects on percentage changes in emission. Is it because of different industrial structures between the CEE and SEA regions? Or is it because of different technology in using resources in CEE and SEA? These need future investigation.

4. The final question is whether there was significantly less environmental deterioration (CO\(_2\) and SO\(_2\) per capita emissions) in transitional economies of CEE than in non-transitional economies of the SEA? The answer is no, according to the data utilized in this study. Even more than 15 years after the collapse of communism, CEE countries are still characterized by much higher pollution than SEA countries.

The regression results of macroeconomic indicators and their percentage changes on environmental deterioration issues can be quite different among regions. In the CEE region, most countries have decreased their CO\(_2\) and SO\(_2\) per capita emissions annually in recent decades. The percentage changes in GDP per unit of energy use and percentage changes in international trade were significant positive explanatory variables of better environmental quality in the CEE countries. An increase in percentage changes in foreign direct investment and an increase in secondary industry to GDP resulted in
environmental deterioration in CEE countries from 1990 to 2003, the most recent data available.

In the SEA region, both per capita emissions of CO₂ and SO₂ have increased from 1990 to 2003, the most recent data available. According to the results of this study, macroeconomic indicators and their percentage changes had different effects on emissions in SEA region. For example, an increase in percentage changes in GDP per unit of energy use resulted in a decrease in percentage changes in CO₂ per capita emissions only. However, there is no such relationship between the percentage changes in GDP per unit of energy use and percentage change in per capita SO₂ emissions from 1990 to 2000. Furthermore, an increase in percentage changes in international trade resulted in an increase in emissions of percentage changes in CO₂ per capita but a decrease in percentage changes in SO₂ per capita emissions in SEA from 1990 to 2003 or the most recent data available. In order to present the regressions results of this investigation, in Table 5-1, the results and significance of research hypotheses 1 and 2 of the study are summarized and in Table 5-2 the results and significance of research hypotheses 3 to 5 are summarized. Table 5-3 presents the results of research hypothesis 6.
### Results and Significance of Research Hypotheses

<table>
<thead>
<tr>
<th>Hypotheses</th>
<th>Results</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GDP per capita</td>
<td>Quadratic GDP per capita</td>
</tr>
<tr>
<td>H1: There is a significant curvilinear explanatory relationship between macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and per capita emissions (CO₂ and SO₂) in the CEE countries from 1990 to 2006, or the most recent data available.</td>
<td>Supported</td>
<td>Yes</td>
</tr>
<tr>
<td>H1a: There is a significant curvilinear explanatory relationship between macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and per capita CO₂ emissions in CEE countries from 1990 to 2003, which is the most recent data available.</td>
<td>Supported</td>
<td>Yes</td>
</tr>
<tr>
<td>H1b: There is a significant curvilinear explanatory relationship between macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and per capita SO₂ emissions in CEE countries from 1990 to 2002, which is the most recent data available.</td>
<td>Supported</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Table 5-1 (continued)

<table>
<thead>
<tr>
<th>Hypotheses</th>
<th>Results</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GDP per capita</td>
<td>Quadratic GDP per capita</td>
</tr>
<tr>
<td>H2: There is a significant curvilinear explanatory relationship between macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and per capita emissions (CO₂ and SO₂) in the SEA countries from 1990 to 2006, or the most recent data available.</td>
<td>Supported</td>
<td>Yes</td>
</tr>
<tr>
<td>H2b: There is a significant curvilinear explanatory relationship between (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and per capita CO₂ emissions in SEA countries from 1990 to 2003, which is the most recent data available.</td>
<td>Partially Supported</td>
<td>Yes</td>
</tr>
<tr>
<td>H2c: There is a significant curvilinear explanatory relationship between (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and per capita SO₂ emissions in SEA countries from 1990 to 2000, which is the most recent data available.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5-2

Results and Significance of Research Hypotheses (Variables in Percentage Changes)

<table>
<thead>
<tr>
<th>Hypotheses</th>
<th>Results</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GDP per capita</td>
<td>Quadratic GDP per capita</td>
</tr>
<tr>
<td>H3: There is a significant curvilinear explanatory relationship between the percent change in macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and the percentage change in per capita emissions (CO₂ and SO₂) of CEE countries from 1990 to 2006, or the most recent data available.</td>
<td>Supported</td>
<td>Yes</td>
</tr>
<tr>
<td>H3₅: There is a significant curvilinear explanatory relationship between the percentage change in macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and the percentage change in per capita CO₂ emissions in CEE countries from 1990 to 2003, which is the most recent data available.</td>
<td>Supported</td>
<td>Yes</td>
</tr>
<tr>
<td>H₃₆: There is a significant curvilinear explanatory relationship between the percentage change in macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and the percentage change in per capita SO₂ emissions in CEE countries from 1990 to 2002, which is the most recent data available.</td>
<td>Supported</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Table 5-2 (Continued)

<table>
<thead>
<tr>
<th>Hypotheses</th>
<th>Results</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GDP per capita</td>
<td>Quadratic GDP per capita</td>
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</tbody>
</table>

H4: There is a significant curvilinear explanatory relationship between the percent change in macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and the percentage change in per capita emissions (CO₂ and SO₂) of SEA countries from 1990 to 2006, or the most recent data available.

H4b: There is a significant curvilinear explanatory relationship between the percentage change in macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and the percentage change in per capita CO₂ emissions in SEA countries from 1990 to 2003, which is the most recent data available.

H4c: There is a significant curvilinear explanatory relationship between the percentage change in macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and the percentage change in per capita SO₂ emissions in SEA countries from 1990 to 2000, which is the most recent data available.

Supported Yes Yes Yes Yes No Yes

Supported Yes Yes No No No Yes
<table>
<thead>
<tr>
<th>Hypotheses</th>
<th>Results</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GDP per capita</td>
<td>Quadratic GDP per capita</td>
</tr>
<tr>
<td>H5: The percentage change in macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and country categories (transitional countries, CEE, and non-transitional countries, SEA) are significant explanatory variables of the percentage change in per capita emissions (CO₂ and SO₂) from 1990 to 2006, or the most recent data available.</td>
<td>Supported</td>
<td>Yes</td>
</tr>
<tr>
<td>H5_a: The percentage change in macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and country categories (transitional countries, CEE, and non-transitional countries, SEA) are significant explanatory variables of the percentage change in per capita CO₂ emissions from 1990 to 2003, which is the most recent data available.</td>
<td>Supported</td>
<td>No</td>
</tr>
<tr>
<td>H5_b: The percentage change in macroeconomic indicators (GDP per capita, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade) and country categories (transitional countries, CEE, and non-transitional countries, SEA) are significant explanatory variables of the percentage change in per capita CO₂ emissions from 1990 to 2000, which is the most recent data available.</td>
<td>Supported</td>
<td>No</td>
</tr>
</tbody>
</table>

### Results of Research Hypothesis 6

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>H6: There are significantly fewer per capita emissions (CO₂ and SO₂) in CEE, transitional countries, than in SEA, non-transitional countries, from 1990 to 2006, or the most recent data available.</td>
<td></td>
</tr>
<tr>
<td>H6ₐ: There are significantly fewer per capita CO₂ emissions in CEE, transitional countries, than in SEA, non-transitional countries, from 1990 to 2003, which is the most recent data available.</td>
<td>Not Supported</td>
</tr>
<tr>
<td>H6₇: There are significantly fewer per capita SO₂ emissions in CEE, transitional countries, than that in SEA, non-transitional countries, from 1990 to 2000, which is the most recent data available</td>
<td>Not Supported</td>
</tr>
</tbody>
</table>


### Implications

The concepts and issues affecting environmental deterioration have been explained, tested, and analyzed throughout this study. This investigation may help policy makers to define their environmental policies more clearly and specifically to realize environmental issues in greater depth, helping them make more efficient and effective policy decisions. Some issues to consider are presented as follows:

1. Improving percentage changes in income: Since an inverted-U curvilinear EKC existed in CEE and SEA, increased percentage changes in income lead to an increase in percentage changes in environmental damage at the beginning, but after per capita income reaches a certain point, the atmospheric quality is expected to improve.
2. Energy efficiency: measured by GDP per capita a more efficient energy use results in a less air pollution in CEE and SEA.

3. Points one and two suggest that environmental friendly government policies could result in an earlier and faster inversion of EKC.

Conclusions

Throughout the research questions and hypotheses, this investigation provided some indication that economic background undermines environmental quality. This analysis also provided quantitative support for the inverted-U curvilinear relationship between percentage changes in income per capita and percentage changes in environmental deterioration in CEE and SEA. In addition, the effects of macroeconomic indicators, GDP per unit of energy use, secondary industry to GDP, foreign direct investment, and international trade, and their percentage changes can vary greatly among regions.

Given these results, even though it has been almost two decades since the CEE reoriented its economic system to market capitalism, countries in the CEE are still characterized by much higher emissions than expected on the basis of their income per capita. The heritage of central planning, over-industrialization, mismanaged industrialization, and economic inefficiency has been so overwhelming that the CEE is still struggling with pollution intensities of GDP when compared with similar income but non-transitional SEA countries.
Limitations

Even though the findings of this investigation regarding economic backgrounds, economic growth, and environmental deterioration in CEE and SEA are fruitful, limitations do exist. For example:

1. This investigation was limited to measuring atmospheric concentrations, in fact, CO₂ and SO₂ per capita, only. Other greenhouse gases such as nitrogen oxide, methane, hydro fluorocarbons, and perfluorocarbons were excluded in this study.

2. This investigation focused on atmosphere; the consequences on other environmental deterioration issues were not addressed, such as loss of biodiversity, desertification, deforestation, and extinction of flora and fauna.

3. This study was based on the existing data; therefore, this secondary data may not coordinate exactly with the research questions and hypotheses to be answered and tested.

4. It took years to collect, calculate, and publish aggregate macroeconomic and emissions data by data publishers, such as The World Bank Group; therefore, the most recent data available in this study ranged widely from 2000 to 2005, depending on variables. As a result, the findings of this investigation reflect historical facts instead of current facts.

5. This investigation utilized macroeconomic indicators only to explain emissions. Other political and social variables, such as urbanization, pollution tax or subsidies, fiscal policies for environmental improvement spending, income inequality and environmental regulations, may have influenced emissions.
6. This study involved 14 countries in two regions—CEE and SEA. Therefore, the results of this investigation may not apply to other transitional economies, such as Albania, Armenia, Bulgaria, Georgia, Romania, and Russia.

7. The quantitative research design may easily over-simplify data through aggregation, comparison, and summarization to meet data analysis standards, which could result in a direct misread of real phenomena. Furthermore, quantification generalizes the phenomena of the real world in ignoring individual specific circumstances. For example, The World Bank data on CO$_2$ is published according to a country average, which ignores specific regions or areas within a country.

8. SEA countries are less homogeneous in terms of income and development than CEE countries. This might cause the average of SEA variables and results to be less reliable compared to CEE averages.

9. All the variables in this study were presented by yearly aggregation, which was less valuable in explaining the diversity of individual variable changes and characteristics.

10. The sample size for some regression analysis was small, affecting the study’s internal validity.

**Recommendations for Future Study**

According to the limitations of this study and changes in the environment, the following recommendations for study are suggested for future inquiry.

1. Indicators of environmental deterioration: future research should include more indicators regarding environmental deterioration issues, such as nitrogen oxide,
methane, hydro fluorocarbons, perfluorocarbons, loss of biodiversity, desertification, deforestation, and extinction of flora and fauna.

2. Population characteristics: This study involved two country categories—transitional and non-transitional. Further studies could enlarge the sample size to cover other transitional economies, such as Albania, Bulgaria, Romania, and Russia.

3. Explanatory variables: Factors regarding political and social variables, such as income inequality, liberalization, urbanization, and regulation, are suggested to provide more perspectives in explaining environmental deterioration.

4. Emission trade: the Kyoto Protocol allows developed economies to purchase quotas of greenhouse gas emissions from non-developed countries. Therefore, CEE or SEA might change their per capita emissions by the trading of greenhouse gas to other countries.

5. European Union membership: Since the eight CEE countries joined the European Union in 2004, the question of whether environmental quality has improved since then needs to be further examined.

6. SEA countries can be grouped into two categories of developed and developing countries. Each group could be compared separately with CEE.

7. Future studies on individual countries of CEE and SEA could remove the problem of average outcomes for two regions.
Summary of Chapter V

Based on the findings of Chapter IV, this chapter, Chapter V, presented a discussion regarding characteristics of the samples, results of the tests, limitations of this study, and recommendations for future study. This study indicated that economic background undermined environmental quality. This study also provided quantitative support for the EKC hypothesis in CEE and SEA. Other macroeconomic variables may have different effects on environmental deterioration, depending on regions and emissions. Government policy makers may benefit from this investigation. Involving more environmental indicators, enlarging the sample size and moderating the grouping, and adopting more political and social variables are suggested for future study to enhance the applications and usefulness of this research.
REFERENCES


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BIBLIOGRAPHY


Appendix A

Authorization of Utilizing Data
May 3, 2007
Pang, Yu-chin

Dear Dr. Stern:

My name is Yu-chin Pang. I am a doctoral candidate in a Ph.D program at Lynn University in Boca Raton, Florida. My major is Global Leadership, with a specialization in corporate and organizational management. My dissertation proposal focuses on the environmental deterioration in developing and less developed countries.

While doing my literature search for the dissertation, I read the excellent articles and data by you, “Global sulfur emissions from 1850 to 2000” Chemosphere, 58(2005), 163-175.

I am writing to request permission to obtain (and purchase if necessary) the data of Global Sulfur Emissions by Country 1850-2003. I am also requesting permission to reproduce the above data in my dissertation. Furthermore, http://www.rpi.edu/~sternd/Chemosphere2005.pdf may supply copies of the dissertation on demand and may make the dissertation accessible in electronic formats.

If you do not control the copyright on all of the above mentioned material, I would appreciate any contact information you can give me regarding the proper rights holder(s), including current address(es). Otherwise, your permission confirms that you hold the right to grant the permission requested here.

Permission includes non-exclusive world rights to translate the scales to use the material and will not limit any future publications-including future editions and revisions-by you or others authorized by you.

If permission is granted, I will include any statement of authorization for use that you request, or provide an APA note of permission to use the scale. The copyright holder will be given full credit.

I would greatly appreciate your consent to my request. If you require any
additional information, please do not hesitate to contact me. I can be reached at the above postal mail address, [redacted] or [redacted] or [redacted].

A duplicate copy of this request has been provided for your records. If you agree with the terms as described above, please sign the release form below and send one copy with the self-addressed return envelope I have provided.

Sincerely,

Yuchin Pang

______________________________

Permission granted for the use of the material as described above:

Yes ☒ No ☐

Agreed to: [redacted]

Name & Title: DAVID STERN, ASSOCIATE PROF
Date: 7/25/07
Appendix B

IRB Approval
Principal Investigator: Yu-Chin Pang
Project Title: Environmental Deterioration and Economic Growth in Central and Eastern Europe and South and East Asian Countries

IRB Project Number_2007-004_ REQUEST FOR IRB EXEMPTION of Application and Research Protocol for a New Project

IRB ACTION by the IRB Chair or Another Member or Members Designed by the Chair

Review of Application and Research Protocol and Request for Exemption Status:
Approved _X_; Approved w/provision(s) ___

COMMENTS
Consent Required: No _X_ Yes ___ Not Applicable ____ Written ____ Signed ____
Consent forms must bear the research protocol expiration date of ________________.

Application to Continue/Renew is due:
(1) For an Expedited IRB Review, one month prior to the due date for renewal _X_
(2) For review of research with exempt status, by a College or School Annual Review of Research Committee ____. If the academic unit ("The Colleges and Schools") where the researcher is assigned does not have a committee in place, the application to Continue/Renew is submitted to the IRB, for an Expedited IRB Review no later than one month prior to the due date.

Name of IRB Chair __________ Farideh Farazmand
Signature of IRB Chair __________ [Redacted] Date: 01/09/2007

Cc. Farideh Farazmand

Institutional Review Board for the Protection of Human Subjects
Lynn University
3601 N. Military Trail Boca Raton, Florida 33431
Principal Investigator: Yu-chin Pang

Project Title: Comparative Analysis of Environmental Kuznets Curve in Central and Eastern Europe and South and East Asia

IRB Project Number: 2007-004

Application for Procedural Revision of or Changes in Research Protocol and/or Informed Consent Form 1 of a Previously Approved Project

Initial Review: Full  Expedited  Exempt  X  Date of most recent continuation approval:

IRB ACTION by the IRB Chair or Another Members Designed by the Chair

Procedural Revision (s): Approved  X  ; Approved w/provision(s)
Referred For Convened Full-Board Review

COMMENTS
Consent required: No  X  Yes  Not Applicable  Written  Signed
Consent Form Revised: No  X  Yes. If yes, the Consent forms must bear the research protocol expiration date of 
Date for Application to Continue/Renew is as noted on initial application or most renewal
Other Comments:

Name of IRB Chair  Farideh Farazmand

Signature of IRB Chair  Date: 6/20/07

Institutional Review Board for the Protection of Human Subjects
Lynn University
3601 N. Military Trail Boca Raton, Florida 33431