WASEDA UNIVERSITY

Essays on the Effectiveness of International Environmental Agreements : Quantitative Analysis on Environmental and Economic Aspects

A THESIS SUBMITTED TO

GRADUATE SCHOOL OF ASIA PACIFIC STUDIES (GSAPS)

IN CANDIDACY FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

BY

YOOMI KIM

TOKYO, JAPAN

February 2014

A thesis

entitled

Essays on the Effectiveness of

International Environmental Agreements

: Quantitative Analysis on Environmental and Economic Aspects

by

Yoomi Kim

submitted to the Graduate Faculty as partial fulfillment of the

requirements for the Doctor of Philosophy Degree in International Studies

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ABSTRACT

An abstract of

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Due to globally intensified environmental degradation, especially in trans-boundary environmental problems, realistic and effective international instruments are necessary to tackle these issues. In this context, International Environmental Agreements (IEAs) have been established as a mode of transnational cooperation for coping with global environmental deterioration and related problems.

However, owing to the persistent self-interested characteristic of international policy, the effectiveness of the IEAs is being questioned. IEAs are established based on consideration of differences in national environmental circumstance, socioeconomic situation, and cultural diversity (Dupuy, 1990). Therefore, voluntary and flexible obligations are imposed. Moreover, decoupling phenomena between IEAs and domestic policy are common.

Harner-Burton and Tsutsui (2005) designate this phenomenon as the “paradox of empty promise”.

Along with the proliferation of IEAs, studies to evaluate the effectiveness of IEAs have increased. However, results from previous studies are still open to dispute due to the difficulties of framing and conducting IEA effect assessments. Furthermore, previous research has mostly been conducting analysis only in consideration of environmental effectiveness, which involves the effect of IEAs in terms of eliminating or reducing pollutants. Therefore, there is a need to broaden research subjects and models to comprehend the effectiveness of IEAs more clearly and broadly in order to qualify the concept of effective international environmental cooperation and work toward this end.

Based on this context, the following main research question arises: *Is there any possibility of establishing IEAs to simultaneously enable sustainable economic development while addressing the adverse effects on the economy? How do IEAs with the notion of common responsibility and differentiated responsibility affect the environmental and economic performance of member countries?* To answer this question, three sub-questions are answered by three essays described from Chapter 3 through Chapter 5.

First, to grasp the effectiveness of IEAs, it is necessary to accurately evaluate the effectiveness of existing IEAs on emission reductions. One of the major limitations of existing literature is the failure to grasp the effect of IEAs controlling for the characteristics of each nation. In this sense, scholars have indicated the intrinsic limitations of predicting the effectiveness of IEAs, such as dealing with hypothetical situations or controlling external factors (Aakvik &Tjøtta, 2011; Frantzi, 2008; Underdal, 1992; Vollenweider, 2013). Therefore, it is necessary to consider the average differences in emissions for participants and non-participants over the periods; thus the following sub-question is addressed. Sub-question 1: *How do IEAs concerning different pollutants affect emission reduction in consideration of the emission reduction trends of participants and non-participants?*

Next, the economic burden caused by pollutant reduction by IEAs is one of the significant considerations when countries decide whether to participate in IEAs (Sprinz & Vaahtoranta, 1994). Indeed, emerging economies are concerned about expected damage to their economies. Therefore, IEAs such as the Kyoto Protocol have recently tried to decrease the negative effect on economic performance with market-based mechanisms. In this regard, the second sub-question is as follows. Sub-question 2: *How much economic burden is placed on member countries by participating in IEAs? Is there any possibility to simultaneously improve economic performance while reducing pollutants of member countries?*

Finally, based on the understanding of the effectiveness of IEAs on environmental and economic aspects, Sub-question 3 seeks evidence of which regime elements of IEAs positively affect the environments and economies of participants. Sub-question 3: *Which regime elements of IEAs have a beneficial effect on the environmental and economic* *performance of member countries?*

This thesis is organized as follows. Chapter 1 provides general information about this thesis including background, research questions, and hypothesis. Chapter 2 reviews previous studies and develops a theoretical framework for evaluating the effectiveness of IEAs. Chapter 3 examines the environmental and economic effectiveness of the IEAs by performing a quantitative assessment on four protocols (the Helsinki, Sofia, Oslo, and Geneva Protocols) of the Convention on Long-Range Transboundary Air-Pollution (LRTAP). The impact evaluation method, which combines the Difference-in-Difference (DID) method with the Propensity Score Matching (PSM) method, was employed in the analysis, using panel data from 50 countries that participated in the 1979 Geneva Convention. The results demonstrate that the Sofia Protocol had a significant effect on both environmental and economic performance while other three protocols had no discernible effect.

Chapter 4 investigates the impact of the Kyoto Protocol on environmental performance and economic improvement using the impact evaluation technique combining the DID and PSM methods, using country-level panel data of 209 countries for the periods from 1997–2008 and 2005–2008. The first hypothesis, which perceives the effect of the protocol in terms of reducing carbon dioxide (CO_2) emissions, is accepted with the result of more effective CO_2 emission reduction among Annex I Parties. In contrast, the second hypothesis, which assumes a positive effect of IEAs on economic performance, is rejected.

From the prediction based on the result of the statistical analysis, emission reductions caused by the Kyoto Protocol exceed the negative effect on Gross Domestic Product (GDP).

Chapter 5 evaluates regime elements affecting the environmental and economic effectiveness of IEAs using databases of 123 IEAs of 23 international environmental regimes based on Breitmeier et al. (2006) and Böhmelt and Pilster (2010). To generate the database of the economic effectiveness on member countries, the impact evaluation technique is conducted for 209 countries from 1970–2008. Regime elements have an effect on the effectiveness of IEAs are identified using the Bayesian methodology with Markov Chain Monte Carlo (MCMC). The result indicates that one of the legalization elements, rule precision, have a negative effect on environmental performance while legally bound IEAs show a significant improvement of economic performance. On the other hand, flexibility mechanisms of IEAs are likely to have a positive impact on both environmental and economic performance of member countries.

This thesis will contribute to a better understanding of the effectiveness of IEAs on member countries in terms of not only environmental effect but also economic respects. With the precise impact evaluation methodologies, the empirical findings in the main chapters could identify the consequences of IEAs with a greater degree of precision. Chapter 6 will synthesize those findings and discuss policy implications.

When you want something,
all the universe conspires in helping you to achieve it.
–Alchemist (1988) by Paulo Coelho

ACKNOWLEDGEMENTS

I am deeply indebted to the many people who supported me for all their help during a long but wonderful academic itinerary. Without their understanding and consideration, this work would not have been completed. I shall never forget their assistance.

First, I would like to express my gratitude to my supervisor, Professor Shunji Matsuoka, for his valuable guidance and generosity throughout the doctorate course. His critical comments and suggestions for improvement of my research have been the driving force behind my academic growth. I sincerely appreciate his special consideration and continuous support throughout the completion of my studies in the trying times following the great east Japan earthquake. I pay reverence to his academic insights and enthusiasm, which serve as inspiration for students who want to become eminent scholars. I will never forget his excellent guidance.

I would like to express my heartfelt thanks to my deputy advisor, Professor Katsuya Tanaka, for his kind teaching, thoughtful comments and warm encouragement. He always kindly and patiently answers my tenacious questions, including my curiosity concerning even the most technical of points. His professional advice and proposal of new perspectives stimulated my intellectual curiosity, and this acted as an impelling force in my research. I greatly appreciate his help to make me overcome the hardest time in the doctoral course and keep me on track to complete this thesis.

I also wish to state my appreciation for the other committee members of my thesis, Professor Shujiro Urata and Professor Atsuyuki Kato, for taking time out of their busy schedule to give insightful advice, driving make further refinements to my thesis as completion approached. Based on their constructive comments, my thesis has been improved in several areas, including not only aspects of contents but also in technical and methodological respects.

I also appreciate sincerely the professors at the Ewha Womans University—Professor Hunmin Kim, Professor Youngbin Song, Professor Heejoon Song, Professor Minah Gang, Professor Geunjoo Lee, and Professor Tak Cho—who have believed in and supported me since my undergraduate studies. Moreover, I also give thanks all members of the Green Technology Center Korea (GTC-K) for affording me the opportunity to enlarge my knowledge through valuable work experience.

I would also like to thank to the faculty members of the Global Institute for Asian Regional Integration (GIARI) of the Waseda University Global Centers of Excellence (COE) Program who provide various opportunities to enrich my academic experience, such as the Waseda University Doctoral Student Network (WUDSN) presentation and many symposiums. Though it was a short period of time, my experiences at these events instilled in me a sense of academic community and inspired me in many respects. I would like to take this opportunity to thank all of my colleagues of GIARI, with whom I share good memories in the most precious in my life.

I am also grateful to Haruhiko Nomura and other staff of the Graduate School of Asia-Pacific Studies (GSAPS). They are always as accommodating as possible in the administrative procedures and cope with procedural problems with thoughtful diligence.

I would like to thank all members of the Matsuoka lab, including the graduates, for their valuable comments and feedback on my work. Moreover, special thanks to Kiminori Hayashi, who deepened my understanding of my major through a regular group study and offered good advice about diverse problems in the beginning of the doctor course.

I warmly thank my valued friends. My best friend, Kiyoko Tadokoro, lends me moral support and affords many chances for diverse cultural experiences in Japan. I also appreciate her family for their warm welcome, even in the difficult conditions after the disaster. I am always grateful to Joohee Lee, who shared my hardest times in Japan and Korea with constant warm-heartedness. I offer special thanks to Eleni Giannakou and Alan Watt, who gave counsel and encouragement when I faced difficulties, and Xiangyun Huang, who I met in the first day at Waseda University by accident without knowing we belonged to the same department, and who is now a congenial colleague. Thanks go to all my dear friends in Korea, Japan, and around the world.

Last, I am deeply grateful to my family for their everlasting love and complete trust in my choices and decisions. I am fortunate to have a wonderful family who offer unstinting

support and encouragement at any time, and anywhere. The fruits of my efforts are attributable to my precious family.

February 2014

Yoomi Kim

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LIST OF ABBREVIATIONS

2SLS	Two Stage Least Squares
ASEAN	Association of Southeast Asian Nations
BEAs	Bilateral Environmental Agreements
CDF	Cumulative Distribution Function
CDM	Clean Development Mechanism
CEIP	Centre on Emission Inventories and Projections
CER	Certified Emission Reductions
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CO_2	Carbon Dioxide
DID	Difference-in-Difference
EANET	Acid Deposition Monitoring Network in East Asia
EC	European Community
EECCA	Eastern Europe, Caucasus and Central Asia
EKC	Environmental Kuznets Curves
EMEP	Protocol on Long-term Financing of the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FGD	Flue-gas Desulfurization
GDP	Gross Domestic Product
GHGs	Greenhouse Gas
GTFP	Green Total Factor Productivity
HPD	Highest Posterior Density
IEAs	International Environmental Agreements
ILO	International Labour Organisation
IRD	International Regimes Database
IV	Instrumental Variable
JI	Joint Implementation
LRTAP	Long-Range Transboundary Air Pollution
MCMC	Markov Chain Monte Carlo
MDG	Millennium Development Goal
MEAs	Multilateral Environmental Agreements
ML	Maximum Likelihood
NGOs	Non-governmental Organizations

NMVOC	Non-methane Volatile Organic Compound
NO_X	Nitrogen Oxide
NSR	Nitrogen Oxide Storage and Reduction
ODA	Official Development Assistance
OECD	Organization for Economic Cooperation and Development
OLS	Ordinary Least Square
OPS	Oslo-Potsdam Solution
POPs	Persistent Organic Pollutants
PSM	Propensity Score Matching
SIs	Sustainability Indicators
SO_X	Sulfur Dioxide
SPM	Suspended Particulate Matter
TFP	Total Factor Productivity
UN	United Nations
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNTC	United Nations Treaty Collection
WCED	World Commission on Environment and Development
WDI	World Development Indicators

CHAPTER 1

Introduction

1.1 Background

Due to globally intensified environmental degradation, especially in transboundary environmental problems, realistic and effective international instruments are necessary. In accordance with the current active discussion about the formation and implementation of global environmental governance, International Environmental Agreements (IEAs) have been established as a mode of transnational cooperation for coping with global environmental deterioration and related problems. It is expected that nations can make progress in improving their environmental performance by participating in IEAs with the object of achieving the common goal of protecting the environment. According to Mitchell's IEA Database Project 2002–2013 (Mitchell, 2013), over 2,500 IEAs currently exist. Moreover, the number of IEAs is anticipated to increase in line with spiraling global pollution.

Along with the proliferation of IEAs, research on IEAs has grown into a major part of regime studies. In particular, the descriptive discussions about IEAs, such as concerning the formation or the implementation of IEAs, have surprisingly increased since the 1970s, with the broad aim of protecting and improving the global environment. In this context, scholars have tried to evaluate the effectiveness of IEAs to grasp a mechanism of implementation of IEAs and, by extension, to consider improvement plans for further sustainable development. However, owing to the persistent self-interestedness of international policy, the effectiveness of IEAs is still being questioned.

IEAs are established based on consideration of differences in national environmental circumstance, socioeconomic situation, and cultural diversity (Dupuy, 1990). Moreover, Buttel (2000) indicates that IEAs have the least impact on national environmental performance, since international agreements do not mean the policy implementation of each nation. Harner-Burton and Tsutsui (2005) designate this decoupling phenomenon between IEAs and domestic policies as the "paradox of empty promises". Participants of IEAs treat IEAs as a kind of ceremonial behavior to avoid the costs caused by pollutant reduction (Meyer & Rowan, 1977). Therefore, it is pointed out that attaining goals and enhancing international cooperation is difficult in international policies due to the voluntary and flexible nature of obligations.

To estimate the effectiveness of IEAs, appropriate methodologies and data sets have been proposed and scrutinized. In line with the development of quantitative methodologies, it is expected that an elaborate quantitative approach can shed light on imprecision about the effectiveness of IEAs by providing empirical evidence. However, due to the scarcity of reliable data and limited statistical methodologies, the analysis of the practical effectiveness of IEAs still has plenty of room for improvement. Thus, empirical results from previous studies are still open to dispute given the difficulties of framing and conducting IEA effectiveness assessments. Furthermore, previous research has mostly conducted analyses only in consideration of environmental effectiveness, which involves the effect of IEAs in terms of eliminating or reducing pollutants, especially air pollution (Aakvik & Tjøtta, 2011; Helm & Sprinz, 2000; Levy, 1993; Murdoch et al., 1997; Ringquist & Kostadinova, 2005; Vollenweider, 2013).

On the other hand, from the perspective of sustainable development, it is required to consider the effectiveness of both the environmental and the economic aspects of IEAs. There is theoretical evidence that supports the supposition that IEAs improve both environmental and economic performance. For example, the Porter Hypothesis demonstrates the possibility that well-made environmental policies can enhance innovation and improve economic efficiency (Esty & Porter, 2001; Golub et al., 2006; Lanoie et al., 2011; Lindmark, 2002; Manne & Richels, 1998; Porter & van der Linde, 1995). In fact, IEAs with market-based mechanisms, such as the Kyoto Protocol, are expected to mitigate the economic burden of participating in IEAs. Therefore, there is a need to broaden research subjects and models to comprehend the effectiveness of IEAs more clearly and broadly in order to qualify the concept of effective international environmental cooperation and work toward this end.

In this context, this thesis evaluates the effect of IEAs not only on environmental improvement but also on economic performance, and the determinants of the effectiveness of

IEAs are investigated. To fulfill this purpose, the first part of this thesis focuses on empirically investigating whether and (if so) how IEAs with the notion of common responsibility and differentiated responsibility improve environmental and economic performance in consideration of pollutant reduction and economic growth trends of participants and non-participants. Therefore, two cases, a traditional IEA and an IEA with market-based mechanisms, are selected: the Convention on Long-range Transboundary Air Pollution (LRTAP) and the Kyoto Protocol, respectively.

Based on the empirical analysis of the effectiveness of IEAs, the second part of this thesis seeks to determine which regime elements of IEAs have a beneficial effect on environmental and economic performance of ratified countries. Legalization and flexibility elements are investigated mainly in this analysis. Moreover, for generalizing the empirical results, the International Regimes Database (IRD), which contains various IEAs (both industrial pollution type and nature conservation type), is used.

The remainder of this chapter is organized as follows. Section 1.2 introduces the main research question and three sub-questions of this thesis. In Section 1.3, the case selection criteria of each main chapter are presented. Section 1.4 briefly proposes the empirical methodologies used in the analyses in the main chapters. Section 1.5 highlights the achievement of this thesis, and the last section, Section 1.6, summarizes the structure of this thesis. To produce reliable empirical evidence, elaborate statistical methodologies are adopted for each main chapter. A conceptual diagram of this thesis is presented in Figure 1.1.

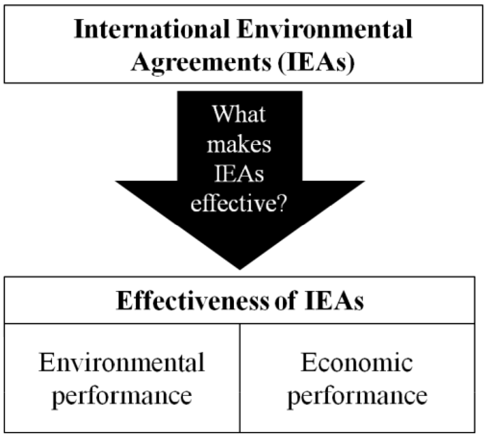

Figure 1.1 **Conceptual Diagram**

Source: Author.

1.2 Research Questions

Investigating the effectiveness of IEAs in a quantitative way with objective data is crucial for establishing better international environmental governance toward sustainable development. However, even though scholars have tried to deliver empirical evidence using various methodologies and databases, they reveal limitations of research objects and quantitative methodologies for assessing the effectiveness of IEAs. Moreover, the environmental influence, such as emission reductions, has been unduly magnified in consideration of the effectiveness of IEAs.

Based on this context, the following main research question arises: *Is there any possibility of establishing IEAs to simultaneously enable sustainable economic development* *while addressing the adverse effects on the economy? How do IEAs with the notion of common responsibility and differentiated responsibility affect the environmental and economic performance of member countries?* To answer these questions, they are divided into three sub-questions, addressed by three essays in Chapters 3, 4, and 5.

First, to grasp the effectiveness of IEAs, it is necessary to accurately evaluate the effectiveness of existing IEAs in terms of emission reductions. One of the major limitations of existing literature is its failure to grasp the effect of IEAs controlling for the characteristics of each nation. On this basis, scholars have indicated the intrinsic limitations of predicting the effectiveness of IEAs, such as dealing with hypothetical situations or controlling for external factors (Aakvik & Tjøtta, 2011; Frantzi, 2008; Underdal, 1992). Therefore, it is necessary to consider the average differences in emissions for participants and non-participants over the periods; thus, the following sub-question is addressed. Sub-question 1: *How do IEAs concerning different pollutants affect emission reduction in consideration of the emission reduction trends of participants and non-participants?*

Next, the economic burden caused by pollutant reduction by IEAs is one of the significant considerations when countries decide whether, and how vigorously, to participate in IEAs (Sprinz & Vaahtoranta, 1994). Indeed, emerging economies are concerned about expected damage to their economies. Therefore, IEAs such as the Kyoto Protocol have recently tried to decrease the negative effect on economic performance with market-based mechanisms. In this regard, the second sub-question is as follows. Sub-question 2: *How much economic burden is placed on member countries by participating in IEAs? Is there any possibility to simultaneously improve economic performance while reducing pollutants of member countries?*

Two cases, which are selected as representative of common responsibility and differentiated responsibility, are estimated in terms of both environmental and economic effectiveness. In this thesis, four protocols of LRTAP (the Helsinki, Sofia, Oslo, and Geneva Protocols), as representative of traditional IEAs with the notion of common responsibility, and the Kyoto Protocol, which applies market-based mechanisms such as emission trading and the Clean Development Mechanism (CDM), are investigated to grasp the effectiveness of IEAs on the environmental and economic performance of member countries.

In addition, there are six possible results concerning the environmental and economic effectiveness of IEAs: 1) Increase both environmental and economic performance, 2) Increase environmental performance but not economic performance, 3) Increase environmental performance but decrease economic performance, 4) Have no effect on environmental performance but increase economic performance, 5) Have no effect on environmental performance but decrease economic performance, 6) Have no effect on either environmental or economic performance.

Finally, based on the understanding of the effectiveness of IEAs on environmental and economic aspects, Sub-question 3 seeks evidence of which regime elements of IEAs positively affect the environments and economies of participants. This thesis focuses on legalization and flexibility theory for categorizing regime elements in order to examine the effectiveness of IEAs on the environments and economies of member countries and shed light on the underlying factors influencing the valid IEAs. Thus follows Sub-question 3: *Which regime elements of IEAs have a beneficial effect on the environmental and economic performance of member countries?*

To answer these research questions, this thesis is designed elaborately with appropriate cases and methodologies. Information about the cases and methods used in this thesis is provided in the following sections.

1.3 Case Selection Criteria

The purpose of this thesis is to empirically evaluate the effect of IEAs on pollutant reduction and economic growth firstly, and thence determine which regime elements have an effect on the environmental and economic effectiveness of IEAs. To investigate the research questions of this thesis (given in the preceding section), the effectiveness of IEAs is estimated in a quantitative way using two cases that are selected under the notion of common responsibility and differentiated responsibility. With these two cases, the environmental and economic effectiveness are estimated in Chapters 3 and 4. Figure 1.2 summarizes the basic information about the case selection status of each main chapter.

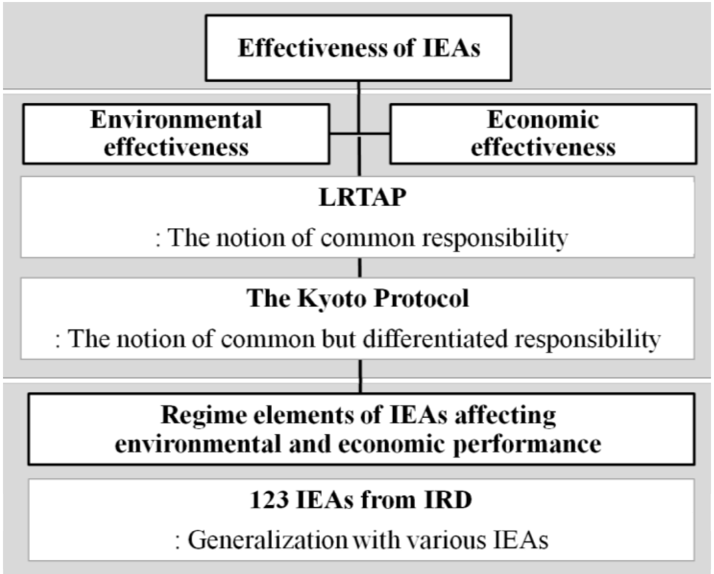

Figure 1.2 **Case Selections**

Source: Author.

The first case was chosen from LRTAP, which is intended to protect the environment against air pollution with the European region as the center. Generally, LRTAP is well known as one of the successful examples of IEAs, while the empirical results about the effectiveness of LRTAP on pollution reduction are still controversial. Four protocols (the Helsinki, Sofia, Oslo, and Geneva Protocols) are extracted for the empirical analysis regarding data availability and research periods. With this analysis, it is possible to obtain results about the effect of IEAs of the different pollutants on environmental improvements and economic performance, since the objective pollutants of each protocol are different. The Helsinki and

Oslo Protocols aim at reducing sulfur dioxide (SO_X) emissions, while the Oslo and Geneva Protocols cover nitrogen oxides (NO_X) and non-methane volatile organic compounds (NMVOC), respectively.

The second analysis in Chapter 4 is conducted with the Kyoto Protocol, which is the best example of an IEA based on the principle of "common but differentiated responsibilities". In particular, the Kyoto Protocol is conceived as the most adventurous IEA in terms of sustainability, and it is thus eminently suited to the purposes of the present thesis. The reason is that this IEA also considers the economic burden of parties that are subject to differentiated responsibility; thus, the mechanisms for mitigating the costs caused by emission reductions are promoted actively. Through the impact evaluation result of LRTAP protocols, it is possible to grasp how the traditional IEAs influence the environments and economies of member countries. Based on this context, the second analysis focuses on the Kyoto Protocol, which is a representative international environmental policy adopting market-based mechanisms, to gauge the possibility of applying the Porter Hypothesis to IEAs.

The last analysis determines regime elements of IEAs that affect the environmental and economic performance of member countries. In this chapter, the research object is extended to various IEAs for drawing a more valid result and generalizing the hypotheses of this chapter. The database on the regime elements of IEAs is limited because it is very difficult to quantify institutional characteristics. Fortunately, Breitmeier et al. (2006) generate the IRD, which contains a wide variety of information on 123 IEAs of 23 regimes, and this database opens the gate for the quantitative investigation of diverse IEAs. Therefore, the last analysis uses this database.

1.4 Method of Analysis

This thesis aims to present empirical evidence to support answers to the research questions using quantitative methodologies. To attain this aim, each main chapter applies advanced statistical methods to estimate the effectiveness of IEAs and determinants of the effectiveness of IEAs. This section briefly introduces information about the methods mainly used in this thesis: the impact evaluation method, the fixed-effect model, and the probit model with the Bayesian approach. Note that more details on each method are provided in the main chapters.

First, the effect of IEAs on environmental and economic performance is evaluated by the impact evaluation methodologies. To overcome the technical limitations of previous studies, the Difference-in-Difference (DID) method combined with the Propensity Score Matching (PSM) method is adopted for the analysis based on Khandker et al. (2010), which compile quantitative methods and practice of impact evaluation. Through the methodologies, it is possible to control not only the problem of selection bias but also the problem of unobserved heterogeneity, since the PSM method constructs a statistical comparison group based on the observed characteristics of each nation. Moreover, the counterfactual situation in the DID method provides the opportunity to estimate influences of IEAs on emission reduction and economic growth more precisely. Figure 3.2 presents a conceptual explanation of this technique. Chapter 3 and Chapter 4 estimate the effectiveness of the protocols of LRTAP and the Kyoto Protocol respectively with country-based panel data. Chapter 5 adopts this method to establish the data on the economic effectiveness of various IEAs. An intensive explanation about theoretical and statistical approaches of impact evaluation methods is offered in Chapter 3.

Second, the fixed-effect model and the probit models are applied depending on the characteristics of the database. In Chapters 3 and 4, the fixed-effect models are conducted in the final steps of the evaluation process based on the result of the Wu–Hausman test. Owing to the database being country-based panel data, it is possible to control time-varying covariates and unobserved time-invariant individual heterogeneity by the fixed-effect models. However, the database of Chapter 5 is agreements-based data, which takes binary values, environmental effectiveness and economic effectiveness, as the dependent variables. In the case of the objective variables with the binary choice, a nonlinear approach, such as the Maximum Likelihood (ML) method, is more suitable than Ordinary Least Square (OLS), which assumes a linear relationship between a dependent variable and an independent variable. Therefore, the probit estimator is applied to investigate the relative influence of various regime elements of IEAs on the environment and economic effectiveness. For more information, refer to the explanation of empirical methods in each main chapter.

Finally, the Bayesian approach compensates for the small sample size and generates robust results in Chapter 5. The database of Chapter 5 is IEA-based data, where fewer than 123 measurements are procured in each variable. As a result, there are not sufficient samples to estimate parameters with the classical statistical methods; thus, methodologies based on frequentist statistics cannot be used as the analyses of Chapter 3 and Chapter 4. The Bayesian method is not based on the assumption of a large sample size, since it assumes the parameters are random variables that can be changed, unlike the classical statistical methods, which consider parameters as fixed and derives inferences from infinitely repeated experiments and data collection. In other words, the Bayesian approach produces the posterior distribution based on the likelihood function about parameter values and the prior distribution. The analysis of Chapter 5 adopts the Bayesian approach with Markov Chain Monte Carlo (MCMC) with Gibbs sampling.

To sum up, this thesis expands the current understanding of the effectiveness of IEAs with advanced quantitative methodologies that provide the opportunity to afford robust empirical proof. Such academic evidence based on the elaborate quantitative analysis provides a better insight into the desirable direction for improving existing IEAs and establishing future IEAs from the perspective of sustainable development.

1.5 Achievements of the Thesis

The need for establishing an effective international instrument for achieving a common goal to protect the environment has grown continuously, in line with intensifying environmental degradation, which transcends national boundaries. IEAs are the most representative institutional instruments for coping with global environmental degradation. However, the effectiveness of IEAs is being questioned owing to the endemic complexities of international institutions. Even though scholars have tried to estimate the effectiveness of IEAs using various methodologies, the empirical findings remain controversial. Therefore, a more advanced and precise quantitative analysis with a broader perspective about the effectiveness of IEAs is required.

In this context, this thesis contributes to a comprehension beyond the effectiveness of IEAs and regime elements affecting the effectiveness by providing empirical evidence from quantitative methods. The significances of this thesis can be emphasized in three respects: extensive scope of the effectiveness, advanced technique, and various research objects.

First, this thesis attempts to evaluate not only the environmental but also the economic aspects of the effectiveness of IEAs from a sustainable development point of view. Since the Brundtland Commission popularized the concept of sustainable development, synergies between the environment, economy, and society have received attention. However, there are concerns that participating in IEAs hinders national economic development, since economic burdens are imposed by IEAs for reducing pollution. Existing studies, especially quantitative studies, have concentrated on the analysis of the effect of IEAs on environmental performance, so it is difficult to find empirical evidence about how much economic burden is placed on member countries by participating in IEAs. Therefore, this study investigates the economic aspect of the effect of IEAs on member countries. In particular, Chapter 4 uses the Kyoto Protocol, which embedded market-based mechanisms to mitigate reduction costs, as a research object and observes the applicability of the Porter Hypothesis. As a result, this study should contribute to a better understanding of the effectiveness of IEAs (on the basis of a more representative set of variables subject to a more sophisticated analysis) to determine the possibility of IEAs that simultaneously enable economic development and pollutant reduction in a sustainable manner.

Second, this study opens up new possibilities of evaluating effectiveness using an advanced technique. The impact evaluation technique combining the PSM and DID methods to estimate the environmental and economic effectiveness of IEAs is conducted in all the main chapters. The impact evaluation technique combining the PSM and DID methods is already employed principally in the fields of official development assistance (ODA). Contemporary scholars of economics and politics also apply these methods to evaluate program effect (Cadot et al., 2012; Michalek, 2012; Mu & Van de Walle, 2007). However, even though this advanced statistical technology is highly acclaimed for its precise analysis results, few studies have used this method to examine the effectiveness of IEAs (Aakvik & Tjøtta, 2011). Thus, previous studies are alleged to have failed to reflect the influence of the external factors of each nation, such as emission trends and other socioeconomic conditions. This thesis overcomes the technical difficulties that cause imprecise estimation results with the reliable and transparent impact evaluation process. As a result, it is possible to analyze effectiveness considering the average differences in emissions and the characteristics of each nation for participants and non-participants over the periods. Moreover, the probit model with the Bayesian methodology allows this study to overcome the requirement of a large sample size, which is critical in the classical statistical methods. Accordingly, it is possible to obtain more reliable empirical evidence by conducting the quantitative analysis regardless of the small sample size of IEAs.

Third, this thesis succeeds in including various research objects that have not been empirically estimated in previous studies. Notwithstanding the significance of evaluating the effectiveness of IEAs, it is true that there are not yet studies that sufficiently establish various IEAs as research objects. Upon reviewing previous quantitative analyses, IEAs belonging to specific areas, such as air pollution, are investigated intensively. Two practical reasons can be conceived. The first reason is data availability. Due to data limitations, certain pollutants with well-established databases are used for empirical analysis. Another reason is that research periods possible for investigating the effectiveness of IEAs are not satisfactory for statistical analysis, where years are a typical unit of measurement. In the latest analysis about evaluating the effect of IEAs, recent IEAs, such as the Geneva Protocol in Chapter 3, are included to expand the research objects and secure a sufficient research period for the impact evaluation. Moreover, the database of various IEAs, which contain both nature conservation type and industrial pollution type, are applied in the analysis, evaluating causality between regime elements and the environmental and economic effectiveness of IEAs. Thus, this thesis assists in widening the understanding of the overall consequences and effectiveness of IEAs.

In conclusion, this academic consideration about the effectiveness of IEAs is deeply significant for enhancing the effectiveness, real and perceived, and further development of IEAs. This study will provide an empirical basis for both domestic and international policymakers. For instance, policy makers of developing countries concerned over the economic burdens caused by participating in IEAs can perceive a bright future from the empirical evidence, which demonstrates that the cost amelioration caused by emission reduction effect of IEAs is much greater than their hindrance on economic growth. From an international perspective, it is expected that the empirical results of this thesis will suggest directions for improving existing IEAs and establishing more effective IEAs in a sustainable manner.

1.6 Structure of the Thesis

This thesis is divided into six chapters. The structure of the thesis is organized as follows. Here, Chapter 1 provided general information about this thesis including background, research questions, and case selection criteria. Chapter 2 introduces the historical trends and research trends in IEAs to widen the understanding of the status of IEAs. Moreover, it provides the achievements and limitations of previous studies that form the basis for this thesis and highlight the need for this thesis. On this basis, a novel theoretical framework for evaluating the effectiveness of IEAs is proposed, and then applied in the three main chapters.

Throughout the three main chapters, the environmental and economic effectiveness of typical examples of "common responsibility" and "common but differentiated responsibility" and determinants affecting the effectiveness of IEAs are examined using the impact evaluation method. Chapter 3 examines the environmental and economic effectiveness of the IEAs by performing a quantitative assessment on four protocols (the Helsinki, Sofia, Oslo, and Geneva Protocols) of the Convention on LRTAP. The impact evaluation method, which combines the PSM method with the DID estimation, was employed in the analysis, using panel data from 50 countries that participated in the 1979 Geneva Convention. The results demonstrate that the Sofia Protocol had a significant effect on both environmental and economic performance, while other three protocols had no discernible effect.

Chapter 4 investigates the impact of the Kyoto Protocol on environmental performance and economic improvement using the impact evaluation technique combining the PSM and DID methods, using country-level panel data of 209 countries for the periods from 1997–2008 and 2005–2008. The first hypothesis, which perceives the effect of the protocol in terms of reducing carbon dioxide (CO_2) emissions, is accepted, with the result of more effective CO_2 emission reductions among Annex I Parties. In contrast, the second hypothesis, which assumes a positive effect of IEAs on economic performance, is rejected. From the prediction based on the result of the fixed-effect regression analysis, emission reductions caused by the Kyoto Protocol exceed the negative effect on the economic growth.

Chapter 5 evaluates regime elements affecting the environmental and economic effectiveness of IEAs using databases of 123 IEAs of 23 international environmental regimes based on Breitmeier et al. (2006) and Böhmelt and Pilster (2010). This chapter focuses on legalization and flexibility to categorize the regime elements of IEAs based on a literature review. To generate the database of the economic effectiveness on member countries, the impact evaluation technique that combines the PSM and DID methods is conducted for 209 countries from 1970 to 2008. Then, Bayesian methodology with MCMC that assumes posterior distribution on the basis of the probability of existing data is applied for gaining a more precise analysis result about the determinants of the effective IEAs. The result indicates that one of the legalization elements, rule precision, has a negative effect on environmental performance, while legally bound IEAs show a significant improvement of economic performance. On the other hand, flexibility mechanisms of IEAs are likely to have a positive impact on both environmental and economic performance of member countries. The overall structure of the main chapter is shown in Table 1.1.

Table 1.1 ***Structures of the Main Chapters***

Chapter	Case	Research question	Data	Method
Chapter 3	LRTAP	Sub-question 1 Sub-question 2	Panel data from 50 countries (1979 Geneva Convention) (1980–2005), IEA Database	PSM, DID, Fixed-effect
Chapter 4	The Kyoto Protocol	Sub-question 1 Sub-question 2	Panel data from 209 countries (1997–2008), IEA Database	PSM, DID, IV
Chapter 5	123 IEAs of 23 regimes	Sub-question 3	IRD data from 123 IEAs Panel data of 209 countries (1970–2008), IEA Database	PSM, DID, Bayesian Probit Model

Source: Author.

This thesis will contribute to a better understanding of the effectiveness of IEAs on member countries in terms of not only environmental effects but also economic respects. With the precise impact evaluation methodologies, the empirical findings in the main chapters could identify the consequences of IEAs with a greater degree of precision. Chapter 6 offers an overview of the study and a concise discussion of policy implications and future research prospects.

CHAPTER 2

Literature Review: Trends in IEAs and Conceptual Definition

2.1 Introduction

IEAs have increased in number and impact significantly since the 1970s, encouraged by two major events: the United Nations Stockholm Conference on the Human Environment in 1972[1] and the Environmental Summit in Rio de Janeiro in 1992[2]. Scholars' interest in the effectiveness of IEAs has increased in line with this trend. IEAs are the one of the representative international institutional instruments for coping with global environmental degradation. Therefore, analyzing and evaluating the effectiveness of IEAs is needed for further sustainable development. However, there are not yet sufficient studies using robust quantitative analysis, and discussions about the practical effectiveness of IEAs, thus, remain controversial.

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[1] "The United Nations Conference on the Human Environment, having met at Stockholm from 5 to 16 June 1972, having considered the need for a common outlook and for common principles to inspire and guide the peoples of the world in the preservation and enhancement of the human environment" (United Nations Environment Programme (UNEP), n.d.).

[2] "The United Nations Conference on Environment and Development, Having met at Rio de Janeiro from 3 to 14 June 1992, Reaffirming the Declaration of the United Nations Conference on the Human Environment, adopted at Stockholm on 16 June 1972, and seeking to build upon it, With the goal of establishing a new and equitable global partnership through the creation of new levels of cooperation among States, key sectors of societies and people, Working towards international agreements which respect the interests of all and protect the integrity of the global environmental and developmental system, Recognizing the integral and interdependent nature of the Earth, our home" (UNEP, n.d.).

Previous studies have primarily been case studies, due to diversity of characteristic of IEAs, and difficulties of collecting data and evaluating the effectiveness of IEAs. However, in line with an increasing number of IEAs and building databases of IEAs, quantitative studies have also been conducted utilizing various methodologies. Matsuoka et al. (2009) also state that building database has enabled scholars to undertake deeper quantitative studies. Quantitative approaches can make up for the weaknesses of qualitative approaches, so quantitative methodologists researching IEAs have tried to grasp causal relationships in IEAs by analyzing numerical data (Mitchell & Bernauer, 1998).

On the other hand, the majority of previous studies have been used the data from particular agreements and focused only on the environmental aspect of IEAs, so they have a limited ability to grasp the overall impact of IEAs. However, in order to improve IEAs more effectively, it is crucial to understand the overall characteristic of IEAs. Moreover, difficulties of framing and conducting IEA effect assessments have been pointed out by scholars who have tried to evaluate the effectiveness of IEAs quantitatively. Ringquist and Kostadinova (2005) argue that a lack of time series data on environmental quality and numerous non-policy factors that influence in environmental performance impede accurate analysis.

Therefore, results from previous studies are also open to dispute. While some scholars have insisted that their results show positive effect of IEAs on environmental performance (Helm & Sprinz, 2000; Murdoch et al., 1997), other studies, which adopt more advanced statistical methods, have raised questions about the actual effectiveness of IEAs using empirical evidence (Aakvik & Tjøtta, 2011; Ringquist & Kostadinova, 2005; Vollenweider, 2013). Therefore, there are strong needs to broaden research subjects and models to comprehend the practical effectiveness of IEAs more clearly in order to establish the shape of effective international environmental cooperation.

This study analyzes the effectiveness of IEAs with the empirical methodologies. Before evaluate the environmental and economic effectiveness of IEAs, keywords must be defined clearly throughout literature review. This chapter establishes conceptual definitions of main ideas and provides a general understanding of historical and research trends in IEAs. Section 2.2 introduces the historical trends, trends by region, and research trends of IEAs to widen the understanding of the status of IEAs. Next, to defines main concepts and verify research gaps, Section 2.3 and 2.4 reviews the literature on the definition of IEAs and the effectiveness. Based on the theoretical discussions, the scope of IEAs is narrowed down in the sustainable development perspective in Section 2.5. Section 2.6 introduces brief information about conditions affecting the effectiveness of IEAs. Finally, Section 2.7 proposes achievements and limitations of existing studies as a point of departure for this thesis.

2.2 Trends in IEAs

This section introduces the trends of IEAs from a historical, a regional, and an academic perspective based on the Mitchell's IEA Database Project (Mitchell, 2013). Mitchell, who is one of the authoritative scholars in the research of IEAs, has built a database of IEAs since 2002 that provides general information about each IEA, such as agreements list, performance data, and other related information. The brief introduction of this database is as follows (Mitchell, 2013):

> The International Environmental Agreements (IEA) Database Project seeks to foster analysis of international environmental agreements (IEAs) by providing a "single source" repository for most information related to IEAs and the evaluation of their influence. Initiated in 2002, the Database seeks to provide negotiators, treaty secretariats, scholars, students, and interested citizens with a reliable list of all historic and current IEAs. IEAs, as defined here, include efforts to regulate human interactions with the environment that involve legally binding commitments ("agreements") among governments ("international" that have environmental protection as a primary objective ("environmental"). (Overview page)

According to Mitchell (2013), over 1,100 multilateral environmental agreements (MEAs) and 1,500 bilateral environmental agreements (BEAs) currently exist as IEAs[3]. By arranging information on IEAs on the bases of this database, this section will be exceedingly illuminating and suggestive in the understanding overall status of IEAs around the world.

2.2.1 Trends by Date. The trends of IEAs with MEAs and BEAs by signature date are investigated first. The history of MEAs started from 1857 with the Agreement respecting the regulation of the flow of water from Lake Constance, which intends to preserve Lake Constance among Austria, Germany (Baden), Germany (Bavaria), Germany (Wurttemberg), and Switzerland. However, the beginning of BEAs was started in 1351 with the Fishery Treaty between England and Castile. It is indisputable since BEAs do not require diverse participants, so it is easier to reach an agreement and can be influenced explicitly by the economic policy or power distribution.

Figure 2.1 presents historical trends in IEAs by year from 1800 to 2012. According to this graph, the number of IEAs has increased significantly, especially in the 1970s and the 1990s.

[3] Accessed on January 27, 2014. The specific summary statistics of IEAs currently in the database except NON-Agreements is as follows: “1210 MEAs, 1598 BEAs, 247 other (non-multi, non-bi) Environmental Agreements” (Mitchell, 2013).

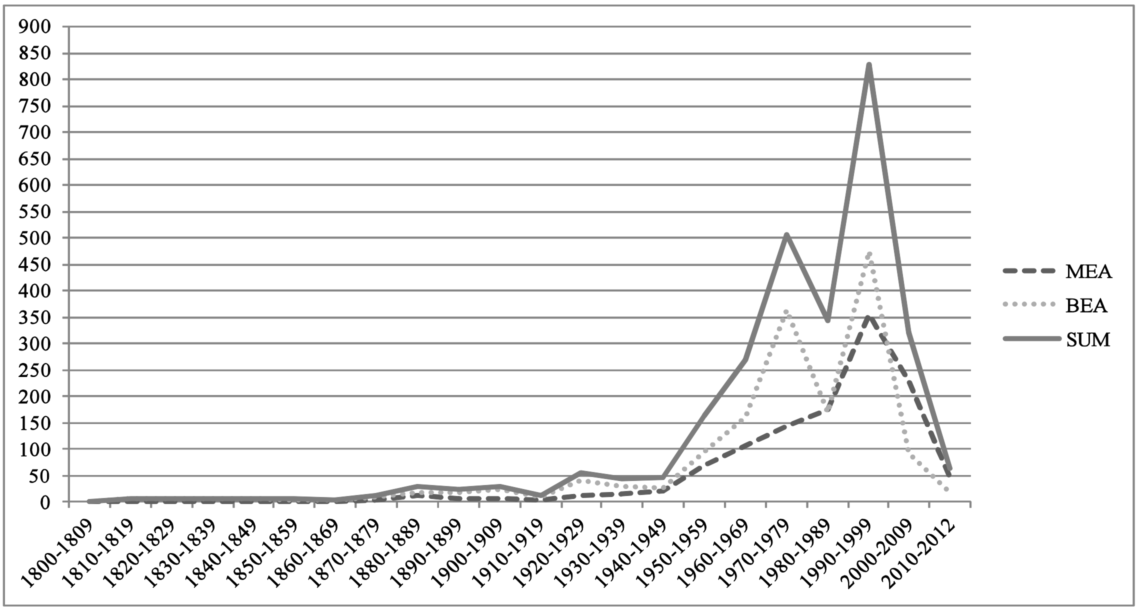


Figure 2.1 **Trends in IEAs: 1970–2010**

Source: Author, based on Mitchell (2013).

This is in line with the argument of Kanie (2007): "[…] the institutionalization of international environmental policymaking really began in 1972, the issues focused mainly on the conservation and management of natural resources, both living and non-living" (p. 68). Even though MEAs and BEAs had existed before 20th century and continuously increased, it is an undeniable that the United Nations Stockholm Conference on the Human Environment in 1972 and the United Nations Environmental Summit in Rio de Janeiro in 1992 are significant events that encourage in participating in IEAs. The specific number of MEA and BEA by year is offered in Appendix 2.1 and 2.2.

Next, Figure 2.2 presents the historical trends of both MEAs and BEAs to examine what kinds of agreements were actively signed. It is important to note that even though

MEAs and BEAs are classified into agreements, amendments, protocols and other mortifications in Mitchell (2013)'s classification, this section focuses on the agreements, amendments, and protocols. From this figure, a significant increase through the 1970s and the 1990s, especially in BEAs, is observed. In the case of MEAs, the number continuously increases until the 1990s, when a ragged pattern is observed in the trend of BEAs. Moreover, the graphs indicate that the compositions of BEAs are weighted towards agreements.

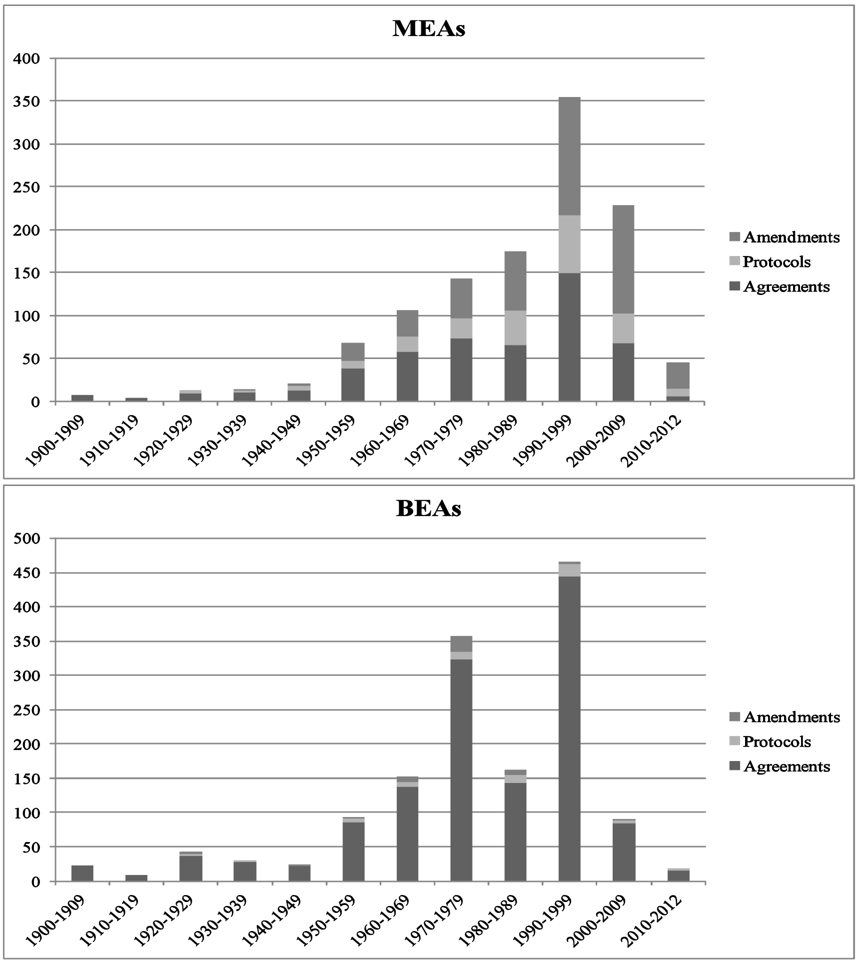


Figure 2.2 **Trends in MEAs and BEAs**

Source: Author, based on Mitchell (2013).

In regards to Table 2.1, which shows the number of both IEA types from 1900 to 2012, the number of amendments and protocols has increased in line with the number of agreements in MEAs. On the other hand, the number of BEAs significantly increased in the 1970s and the 1990s, especially the number of agreements. That is, the number of agreements of BEAs in the 1970s is 323, while it is 138 in the 1960s. Moreover, a rapidly increasing number of agreements of BEAs are also observed in the 1990s. Accordingly, it is believed that the influence of the Stockholm Conference and the Environmental Summit in Rio de Janeiro on BEAs is clearer than MEAs, even though both critical events have clearly promoted IEAs in the world.

Table 2.1 ***Number of MEAs and BEAs***

	MEAs			**BEAs**		
	Agreements	**Protocols**	**Amendments**	**Agreements**	**Protocols**	**Amendments**
1900–1909	7	0	0	23	0	0
1910–1919	4	0	0	9	0	0
1920–1929	9	3	0	37	3	2
1920–1939	10	2	2	28	2	0
1940–1949	12	6	2	22	1	1
1950–1959	38	9	21	86	6	1
1960–1969	58	17	31	138	7	7
1970–1979	73	24	46	323	12	22
1980–1989	65	41	68	144	11	7
1990–1999	150	67	137	445	17	4
2000–2009	68	34	127	85	4	1
2010–2012	6	9	30	16	2	0

Source: Author, based on Mitchell (2013).

2.2.2 Trends by Region. Another important factor, which demonstrates the trends of IEAs, is the status of participating countries. To provide the present situation of participating nations in IEAs and to grasp the differences between Asia and Europe, member countries of IEAs are picked out and divided into the Association of Southeast Asian Nations (ASEAN) and the European Union (EU).

The results about trends by region are presented in Table 2.2. ASEAN countries[4] and China, Japan, and South Korea are included under the ASEAN plus three category, while 27 European member states[5] are included under the EU membership category.

Table 2.2 ***Number of Membership Actions in Asia and Europe***

	Number of countries	Actions taken on agreements	Actions taken on agreements per country
ASEAN plus three	13	2,944	226.462
EU membership	27	10,603	392.704

Source: Author, based on Mitchell (2013).

Note: Actions taken on Agreements include Signatures, Ratification, Accession, Succession, or Similar, and Entry into Forces.

[4] Brunei Darussalam, Indonesia, Malaysia, Philippines, Singapore, Thailand, Myanmar, Cambodia, Lao People's Democratic Republic, Viet Nam.

[5] Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia ,Slovenia, Spain, Sweden, and United Kingdom of Great Britain, Northern Ireland.

The number of actions taken on agreements of the EU membership countries is 10,603, which is more than three times those of the ASEAN plus three countries. The third column of the table, which indicates the number of membership actions per countries, demonstrates that almost 393 IEAs per country are observed in the EU membership countries, whereas approximately 226 IEAs are observed in the ASEAN plus three countries. To conclude, this result indicates that IEAs are promoted and implemented more actively in Europe. This verifies the structural vulnerability of formal international environmental governance in Asia.

The status of participating countries in IEAs has the following policy implications. It is expected that the need to establish IEAs will increased in Asia, since many developing countries, such as China, remained. Jha and Whalley (2001) argue about the necessity of the environmental regimes in developing countries, elaborating the situation of expected global environmental externalities affecting developing countries. This is shown below in Table 2.3. It is observed that the effects of global environmental changes (such as climate change) wield greater influence upon developing countries than developed countries, which have capacity to deal with environmental problems. This is one of the reasons an environmental regime is needed in Asian.

Table 2.3 ***Transborder and Global Environmental Externalities Affecting Developing Countries***

Global warming	Temperature rise and microclimate change, combined with increased frequency of extreme weather events
Ozone depletion	Thinning of ozone layer increases ultraviolet-light penetration of the atmosphere; effect more severe in temperate climates
Biodiversity loss and deforestation	Loss of gene pool through forest and wildlife erosion (e.g., mangrove losses linked to shrimp farming); loss of forests affects local populations who use nontimber forest products, reduces carbon absorption by forests, and increases water runoff in flooding
Acid rain	Airborne acid depositions; high in areas such as south and east China, north and east India, Korea, and Thailand (e.g., wheat yields halved in areas of India close to SO_2 emissions)

Source: Jha and Whalley (2001).

However, as Table 2.2 depicts, the degree of participation in IEAs of Asian countries is considerably lower than that of European countries, despite an increasing number of IEAs. Moreover, discussions about the effectiveness of IEAs in Asia are still controversial and studies about the Asian region itself are not sufficient. It is necessary for environmental management in East Asia to be underpinned by a legal framework, such as IEAs. Loose systems, such as the Acid Deposition Monitoring Network in East Asia (EANET),[6] do not depend on legally binding conduct and, at present, no IEAs specialize in the Asian region. For

[6] EANET is established for "creating a common understanding of the state of the acid deposition problems in East Asia, providing useful inputs for decision making at local, national and regional levels aimed at preventing or reducing adverse impacts on the environment caused by acid deposition, and contributing to cooperation on the issues related to acid deposition among the participating countries." 13 countries are participating in EANET; Cambodia, China, Indonesia, Japan, Lao P.D.R, Malaysia, Mongolia, Myanmar, Philippines, Republic of Korea, Russia, Thailand, Vietnam (EANET, n.d.).

sustainable development in Asia, a greater number of international environmental governances are required. To enhance environmental cooperation, these must accompany economic cooperation.

2.2.3. Research Trends. This section introduces the brief trends of previous studies on IEAs. The section after will focus on the previous studies pertaining to the effectiveness of IEAs. Along with an increasing number of IEAs, the studies about IEAs have grown into a major part of regime studies. Especially, the descriptive discussions above demonstrate that IEAs have surprisingly increased since the 1970s. This increase has materialized to protect the global environment, in line with a global consensus on environmental issues. According to Zürn (1998), “[i]mportant comparative studies on environmental policies were undertaken soon after the rise of environmental politics, and the mid-1980s saw the beginnings of significant research on international environmental politics” (pp. 671–618).

The early stages of IEA studies focused on the conditions of IEA formation (Young, 1989; 1991). After this, the implementation of IEA began to be examined. Recently, many scholars have tried to evaluate the effectiveness of IEAs in both a qualitative and quantitative manner (Ringquist & Kostadinova, 2005). Previous studies about IEAs have been concentrated on case studies. However, it is difficult to generalize and grasp the results from qualitative analyses. Zürn (1998) points out the limitations of the qualitative approach, insisting that there is a need to adopt comparative designs to the analysis of the effectiveness:

> Although the research strategy of tracing causal mechanisms is most helpful when it is applied to more than just one case study, its logic is also different from comparative designs. A comparison is a quasistatistical approach that ought to solve the "ratio of number of variables to cases" problem that is inherent in qualitative case-study research. It uses the notion of correlation in order to test hypotheses, thus relieving single-case studies of the task of making causal claims. (p. 641)

In line with generating reliable database, quantitative studies have been conducted using various quantitative methodologies (Aakvik & Tjøtta, 2011; Helm & Sprinz, 2000; Levy, 1993; Murdoch et al., 1997; Ringquist & Kostadinova, 2005; Vollenweider, 2013). Matsuoka et al. (2009) also mention that building a numerical database about IEAs has enabled scholars to conduct more thorough quantitative studies (Breitmeier et al., 2006; Mitchell, 2013). Even though previous studies, which have aimed to estimate the effectiveness of IEAs in quantitative ways, are concentrated on specific examples, the effect of IEAs on pollutant reduction is still disclosed with empirical evidence. It is true that due to the diverse characteristic of IEAs, there are difficulties in collecting data and evaluating the effectiveness. Accordingly, the qualitative methodology is believed to have been applied in few cases, such as the LRTAP (Mitchell & Bernauer, 1998).

The previous quantitative researches can be divided into two categories: previous studies on the practical effectiveness of IEAs and previous studies on conditions for effective IEAs. This classification provides an understanding of the trends of the research object in IEA studies. Unlike an analysis of the practical effectiveness of IEAs, it tries to examine the relationship between IEAs and environmental performance. In other words, the effectiveness of IEAs on reducing pollutants and an analysis of conditions for effective IEAs is aimed at defining the conditions that make IEAs effective. For example, previous studies about the effect of IEAs have paid attention to the existence of sanction mechanism or the number of participating countries. Figure 2.3 shows the research trends of previous studies on IEAs.

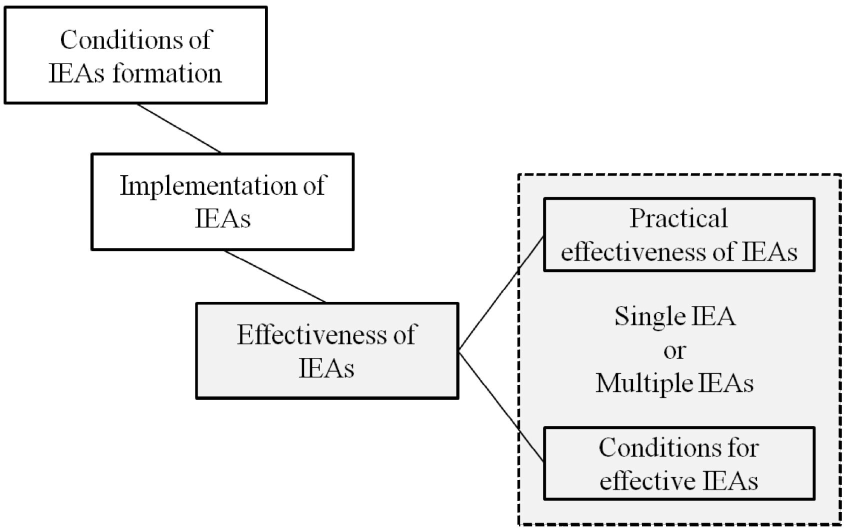


Figure 2.3 **Research Trends of Previous Studies on IEAs**

Source: Author.

From a wider perspective, some scholars have identified the possibility of regime interplay and, eventually, consequences of regimes from a broad and long-term point of view. For example, Underdal and Young (2004) suggest scopes and units for regime consequences as Table 2.4. They categorize the consequences of regimes as single regime, cluster of regimes and universe of regimes. For each unit, the scopes are divided into four areas: regime domain, other issue area, party and the international system. Their comprehensive understanding of fields of regime consequences shows an infinite amount of possibilities in the field of IEAs, but it is true that the researches about this issue still face many difficulties due to the scarcity of resources.

Table 2.4 ***Fields of Regime Consequences***

		Scope: Consequences for			
		Regime domain	**Other issuearea (s) or regime(s)**	**Party (State, society, individual)**	**The international system**
Units: Consequences of	**Single regime**	Effectiveness, robustness	Externalities, interplay	-	-
	Cluster of regimes	Effectiveness, robustness	Externalities, interplay	Political system; actor identity; human welfare.	Structure and processes. State of affairs (e.g.peace).
	Universe of regimes	◆	◆	Political system; Actor identity; human welfare.	Structure and processes. State of affairs.

Source: Underdal and Young (2004).

Note. "-" indicates "questions rarely asked", "◆" indicates "not applicable".

With a modern academic trend toward convergence of different disciplines, there have been attempts to investigate the linkage between environmental agreements and agreements of different fields, such as the relationship between economic agreements and environmental agreements. Even though studies in this respect are in their infancy, they are expected to shed greater light on the problem of grasping the effectiveness of IEAs.

2.3 What Are IEAs?

2.3.1 Definitions of IEAs. Prior to an empirical analysis about the effectiveness of IEAs, it is necessary to provide a clear definition of IEAs based on the theoretical review. Mitchell (2003) provides the general definition of IEAs, encompassing broad consideration about components of the term itself: "legally binding intergovernmental efforts directed at reducing human impacts on the environment" (p. 429). In this definition, legally binding agreements, such as conventions, treaties, and protocols for protecting the environment are included in the scope of IEAs.

Furthermore, Mitchell's IEA Database Project provides "a single source repository for most information related to IEAs and the evaluation of their influence" (Mitchell, 2013, Overview page). It also provides word-by-word definitions of IEAs. Since this database is used in a process to determine a wide range of information, such as the status of the participation, this section introduces the definitions of IEAs provided by Mitchell (2013).

These are used to narrow the scope of the IEAs considered in this thesis.

First, Mitchell demonstrates that international includes “all agreements to which governments of two or more states have (or are allowed to) become parties but excludes instruments between single governments and non-governmental organizations (NGOs), between single governments and international organizations, and between or among corporations, NGOs, or international organizations” (Mitchell, 2013, Definitions page). However, this thesis focused only on the agreements that are validated by more than two states. The reason for this is that the impact evaluation method of this thesis is required to define the region of common support and balancing tests in the calculation of the propensity score. Therefore, for this process, the observed characteristics of research objects (nations, in this thesis) have to be set. Accordingly, IEAs by non-governmental organizations, such as NGOs, cannot be included in the analysis of this thesis.

Second, Mitchell’s IEAs database (Mitchell, 2013) covers a wide range of IEAs related to environment with six categories: nature-general environmental protection, species, pollution, habitat and oceans, freshwater resources, energy, nuclear issues, and conflict. However, this thesis concentrates on IEAs that are directly related to the quality of environment with for the explicit aim of improvement. As a result, the category of energy production and conflict is far removed from this thesis. In addition, in chapters 3 and 4, it is necessary to estimate the effect of IEAs on pollutant reduction. Hence, IEAs that aim at decreasing pollutants, are adopted for the research objects.

Finally, "agreement" is defined based on the 1969 Vienna Convention on the Law of Treaties' definition. This states that a treaty is defined as "an international agreement concluded between states in written form and governed by international law" (Mitchell, 2013). The operationalized definition is as follows:

- instruments designated as convention, treaty, agreement, accord, or their non-English equivalents, and protocols and amendments to such instruments;
- instruments, regardless of designation, establishing intergovernmental commissions;
- instruments, regardless of designation, identified as binding by reliable sources (e.g., by a secretariat, UNEP, or published legal analysis); or
- instruments, regardless of designation, whose texts fit accepted terminologies of legally-binding agreements. (Definitions page)

More specifically, this database judges a scope of agreements based on terms in Table 2.5. As Table 2.5 demonstrates, many similar expressions offer the same definition of agreement. This thesis covers all categories: agreement, amendment, other modification, and protocol. IEAs and informal agreements are not considered. Therefore, the IRD used for the analysis in Chapter 5 covers from convention to amendment, as per the range in Table 2.5.

Table 2.5 ***What Is Agreement?***

Category	Search terms used
Agreement	Accord, Act-Agreement, Act-Commission, Act-Treaty, Acuerdo, Adjustment, Agreement, Arrangement-Agreement, Articles of Association, Charter-Agreement, Constitution, Convencion, Convenio, Convention, Convenzione, Covenant, Exchange of Letters Constituting An Agreement, Exchange of Notes Constituting An Agreement, Grant Agreement, Instrument, Interim Agreement, Interim Arrangement, Interim Convention, Loan Agreement, Provisional Understanding, Statute, Statute-Commission, Supplementary Treaty, Tratado, Treaty
Amendment	Agreement-Amendment, Amendment, Arrangement-Amendment, Extension
Other modification	Denunciation, Exchange of Letters Modifying an Agreement, Exchange of Notes Modifying an Agreement, Proces-Verbal
Protocol	Optional Protocol, Protocol, Protocole, Protocolo, Supplemental Agreement, Supplementary Agreement, Supplementary Arrangement, Supplementary Protocol

Source: Mitchell (2013).

Nevertheless, the protocol level, such as the Helsinki Protocol of LRTAP and the Kyoto Protocol, are mainly focused as the research objects in chapters 3 and 4. The reason for this is that the specific context, which can be quantified in the numerical database, is usually produced in the protocol level, not in the convention level. For instance, Chapter 3 investigates the effectiveness of IEAs by analyzing four protocols, since each protocol contains a clear goal of emission reductions and a target year.

2.3.2 Principles of IEAs. This section focuses on the principles of IEAs for grasping the origin of establishing IEAs. “Common responsibility” and “common but differentiated responsibility” are two of the basic IEA principles that are related to the cases of this thesis.

Most IEAs are based on the notion of “common responsibility”. Common responsibility is rooted in the principle of co-operation. This posits that states are obliged to cooperate and that such cooperation is in the spirit of solidarity underpinning prevent transboundary pollution (Rajamani, 2000). From the notion of “common concern”, the default option in international negotiations seems to be the principle that all parties should have equal obligations. For example, the Conventions on Biological Diversity and the Convention on LRTAP make participating countries responsible for emission reductions (Rajamani, 2000; Ringus et al., 2002).

On the other hand, from an equality perspective, imposing equal reduction obligation, regardless of the socioeconomic situation of each country, is blamed for preventing active participation and lowering the effectiveness of IEAs. To encourage participation and enhance the effectiveness of IEAs, the notion of “common but differentiated responsibility” has been recently adopted in the provision of IEAs. The United Nations Conference on Environment and Development met at Rio de Janeiro from the third to 14 June 1992, to establish a new and equitable global partnership through the creation of new levels of cooperation among states, key sectors of societies and people. According to Rajamani (2000), the notion of common but differentiated responsibility has been specified in the Rio Declaration on Environment and Development (UN, 1992) as follows:

States shall cooperate in a spirit of global partnership to conserve, protect and restore

> the health and integrity of the Earth's ecosystem. In view of the different contributions to global environmental degradation, States have common but differentiated responsibilities. The developed countries acknowledge the responsibility that they bear in the international pursuit to sustainable development in view of the pressures their societies place on the global environment and of the technologies and financial resources they command. (Principle 7)

The notion of differentiated responsibility derives from both the differing contributions of states to climate change and the differing capacities of states to take remedial measure (Rajamani, 2000). Therefore, differential treatment for developing countries is imposed. The Kyoto Protocol is one of the representative examples that contain the notion of common but differentiated responsibility. It adopts market-based mechanisms in consideration of mitigating the economic burden by differentiated responsibility.

With this in mind, this thesis adopts the LRTAP regime and the Kyoto Protocol, representative examples of the notion of common responsibility and common but differentiated responsibility as the research objects of chapters 3 and 4. It is expected that the academic curiosity that shows how IEAs with different pollutants affect emission reductions and economic burdens of member countries can be revealed.

2.4 What Is IEA Effectiveness?

This section introduces various discussions about the effectiveness of IEAs based on variety previous studies. This section proceeds as follows. The definition and conceptual discussions about the effectiveness of IEAs are introduced, and then the components of IEAs that affect the effectiveness are considered from the policy elements point of view. Lastly, representative conceptual models for a quantitative analysis of the effectiveness of IEAs are proposed.

2.4.1 Theoretical Discussions about the Effectiveness of IEAs. The dictionary definition of effectiveness is the "capability of producing a desired result". However, "effectiveness emerges as an elusive concept construed quite differently by various analysts" (Levy et al., 1995, p. 291). In the field of IEAs research, Young (1999) offers a general remark on the definition of the effectiveness. He mentions that the broad meaning of effectiveness is "a matter of the contributions that institutions make to solve the problems that motivate actors to invest the time and energy needed to create them" (p. 3). Moreover, Underdal (2004) insists that there are key concepts in literature on regime effectiveness, even though profound confusion is observed in the vocabularies and concepts. For instance, while the concept of effectiveness is dealt with different meaning, some words, such as strength or robustness, are used as similar concepts. Underdal (2004) reviews about similar terms of effectiveness, he conceptualizes critical determinants of effectiveness into three main clusters: 1) the nature of the problem, 2) characteristics of the group of parties, 3) properties of the regime itself.

Based on the theoretical discussions of the approach for the concept of the effectiveness of IEAs, several researchers have discussed about how the effectiveness of IEA can be estimated. In this instrumental perspective, scholars try to determine the criteria for classification about the concept of effectiveness and investigate what and which consequences of IEAs can be evaluated. Young (1999) disaggregates the effectiveness of IEAs into five approaches based on his definition of the effectiveness. He mentions that the effectiveness of IEAs can be measured in several manners depending on what aspect of the effectiveness observed mainly. First, a problem solving approach considers the effect of IEAs as eliminating or reducing environmental problems. Second, from a legal perspective, if contractual obligations written into treaty language are met, a legal approach is satisfied. An economic approach regards highly cost efficiency, and consequently less costly adjustment is more effective. A normative approach that attaches importance to normative principles and a political effectiveness approach that places value in changes behavior of actors are also introduced.

In the discussion of Zürn (1998), the regime effectiveness and broader regime consequences are a subtle but important difference. He claims that "[a]lthough regime effectiveness is still an ambiguous concept, it refers mainly to those intended and issue area-specific outcomes of the regime In contrast, regime consequences refer mainly to the more general impacts of the regime, whether intended or unintended, issue-area specific or general" (p. 63). In his argument, the effectiveness of a regime is a more issue specific concept, while regime consequences refer more general concept including the behavior, the distribution of capacities, the cognition of different factors and the types of targets. Based on his theory, he also categorizes according to relevant areas: government, society/ domestic politics and issue-area. The categorized dependent variables are suggested as Table 2.6.

Table 2.6 ***Dependent Variables for the Study of Regime Consequences***

Target dimension	Government	Society/ Domestic politics	Issue-area
Behavior	implementation of regime rules; compliance with inconvenient commitments	groups supporting regime rules; rule compliance by new governments	problem solving; resilience against external changes
Capabilities	resources at government's disposal	domestic distribution of resources	resources at disposal for the international endeavor
Cognitions	cause-effect relationship regarding issues; intentions ascribed to other actors	cause-effect relationship regarding issues; intentions ascribed to other actors	cause-effect relationship regarding issues; mutual trust
Values and interests constitution	preference ordering domestic political structure	domestic interests loyalties	situation structure integration/process of civilization

Source: Zürn (1998).

Helm (1999), who investigates a model for estimating the effect of global environmental regimes, defines ideal minimal requirements of the regime effectiveness based on previous studies on conceptualization of regime effectiveness. He demonstrates that following factors have to be satisfied: 1) conceptual definition, 2) ease of operational measurement, 3) comparability across time and issue areas, 4) the ability for aggregate (regime-wide) performance measures as well as disaggregated (country-level) measures to be taken in a nested way. Meanwhile, Underdal (2004) demonstrates that there are three main questions about the object, the standard, and mode of inquiry in developing a methodological framework for assessing the regime effectiveness:

> Any attempt at developing a methodological framework for such an exercise must, then, address at least three main questions. First, what precisely is the object to be assessed? Second, against which standard is this object to be evaluated? And, third, how do we—in operational terms—go about comparing that object to the standard we have defined? Methodological approaches to the study of regime effectiveness can be described and distinguished in terms of their answers to these three questions. (p.31)

Moreover, according to Miles et al. (2002), if a regime achieves a certain missions or resolves problems, that regime can be conceive as effective. He categorizes three dimensions of regime effectiveness (Figure 2.4).

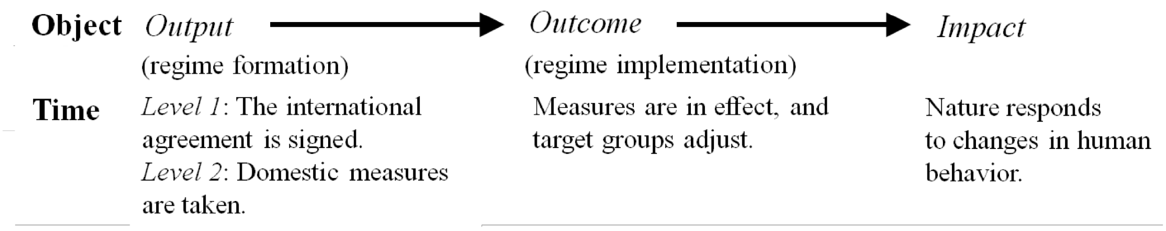


Figure 2.4 **Regime Effectiveness**

Source: Miles et al. (2002).

First, "output" is related with the process of regime formation. In fact, principles and conceptual frameworks are established in the early stages of IEAs studies (Underdal, 2002; Young, 1989; Young, 1991). Second, "outcome" is judged by the implementation behavior of institutions, not evaluated by environmental quality directly (Mitchell, 2008). Last, "impact" is "how nature responds to changes in human behavior". This is measured improvement in environmental performance, such as emission reductions. Figure 2.4 presents the concept of regime effectiveness which is included output, outcome, and impact. According to Miles et al. (2002), these three distinctive steps are included a "causal chain of events".

Karlsson-Vinkhuyzen and Vihma (2009) suggest two dimensions of measuring the effectiveness. The first dimension is observed the degree to which they achieve that goal. The other way to measure the effectiveness is to "see how effective the norm is in changing the behavior of states and other actors" (p. 405). This approach is not far off previous studies above. They also refer these two dimensions of effectiveness as problem-solving effectiveness (impact) and behavioral effectiveness (outcome).

2.4.2 The Effectiveness of IEAs with Policy Elements Perspective. This section discusses the effectiveness of IEAs in the policy elements point of view. Since this thesis regards IEA as an environmental policy, which covers an international environmental problem, it is possible to discuss within the framework of the components of the policy, which is discussed in the field of policy studies. Therefore, IEAs can be screened a variety of factors on three elements: the policy goal, the policy instrument, and the policy objects, which are demonstrated by Rho (2012).

The first element, the policy goal, means the direction and the desired state of the future policy to be achieved. Therefore, the policy goal of IEAs is the reduction of pollutants that each treaty concerns, which is an improvement of environmental quality. In general, the policy goal of IEAs is specified in such provisions of the context of IEAs, and shared by participating countries. For example, an agreement is intended to establish the degree of legal binding and the understanding of the people on environmental issues; thus, precision of IEA can be discussed as factors related to the policy goal of IEAs. Previous studies, which focus on the regime effectiveness, insist that those factors have an effect on the effectiveness. For example, if the treaty subject to the consensus is formed, it is likely to be an effective agreement with the development of technology-related policies (Breitmeier et al., 2006). Moreover, the more legally binding IEAs and more precise IEAs show better effectiveness (Abbott et al., 2000; Böhmelt & Pilster, 2010; Hafner-Burton, 2005). It is noteworthy that, unlike domestic policy, the policy goal of IEAs, the degree to which they are legally binding and the understanding of the problem, can differ distinctly between agreements.

Next, the policy instrument implies any type of scheme for achieving policy objectives. IEAs carry out activities, such as the decision-making and implementation of policy through the secretariat or decision-making entity of the each IEA, to achieve success in environmental improvement. Especially, the secretariat is a mechanism typical to organize government of the IEA in general and management of participating countries and the implementation of the agreement. Since a variety of needs and problems are aggregated in IEAs, the Secretariats of the IEA are one of the factors represented by the institutional features of IEAs (Easterly & Pfutze, 2008). In addition, Böhmelt and Pilster (2010) state that since IEAs offer a flexible mechanism, such as emissions trading system under the Kyoto Protocol, the utility of flexible mechanisms is discussed. Wendt (2001) also demonstrates that there is a tendency for a stronger regulation adoption in agendas with a flexible mechanism.

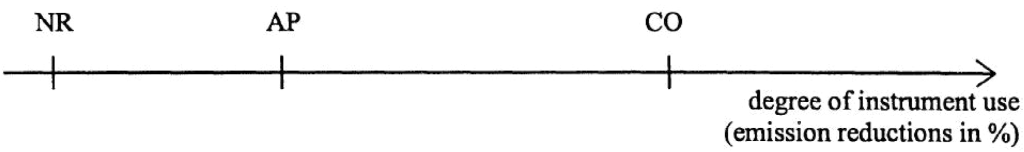
The last policy component, the policy objects, indicates certain targeted group of a policy. Representatively, the characteristics of the environmental issues those are subject to IEAs can be considered. IEA is a collective behavior to protect the international environment. Olson (1965) demonstrates that in such collective behaviors in IEAs of large-scale population with many members, it is usually shown that objectives of the population lose momentum because of increasing free riders. However, rooms for discussions are remained that how the large numbers of participating countries influence the effectiveness of IEAs.

2.4.3 Conceptual Models about the Effectiveness of IEAs. There are scholars who tried to specify conceptual models about the effectiveness of IEAs through establishing the measurement models practically based on the theoretical discussions. This section introduces representative conceptual model about the effectiveness of IEAs. With discussions in this section, it is possible to establish the foundation for the quantitative analysis of this thesis.

The Oslo-Potsdam solution (OPS) for measuring regime effectiveness is the representative way of calculating the effectiveness of IEAs. This method is generated from Helm and Sprinz (2000), who derive this measurement concept and estimate the effectiveness of the Helsinki and Sofia Protocols. In their study, the definition of regime effectiveness is "improvements in the object of evaluation (the dependent variable) that can be attributed to the regime" (p. 636). For estimating the effectiveness, "degree of instrument use" is used as measurement standard and the degree of pollution reduction is one option for IEAs based on previous studies (Karlsson-Vinkhuyzen & Sylvia, 2009; Miles et al., 2002; Young, 1999). These studies propose that the effectiveness can be measured by improvement in environmental performance in the instrumental perspective on regime effectiveness, as measurement tool of the effectiveness of IEAs.

Figure 2.5 depicts the model named Oslo-Potsdam Solution generated by Helm and

Sprinz (2000). According to this model, the simple effectiveness is evaluated by the distance between the collective optimum[7] and actual policies. An effectiveness score (E) is calculated "the relative distance that the actual performance (AP) has moved from the no-regime counterfactual (NR) toward the collective optimum (CO) or as the percentage of the regime potential that has been achieved" with the score from 0 to 1[8]. Moreover, a sensitivity of effectiveness score (S) is "absolute change of the effectiveness score resulting from a change in the actual performance (AP) by one percentage point" (Helm & Sprinz, 2000, p. 636).



Effectiveness score $E = \frac{AP - NR}{CO - NR}$

Sensitivity of effectiveness score $S = \frac{AP + 1 - NR}{CO - NR} - E = \frac{1}{CO - NR} = \frac{dE}{dAP}$

Figure 2.5 **Oslo-Potsdam Solution for Measuring Regime Effectiveness**

Source: Miles et al. (2002).

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[7] "The degree of instrument use that would have been obtained by a perfect regime" (Helm & Sprinz, 2000).

[8] "If the Nash solution coincides with the Pareto optimum, the index of tragedy is 0, and if the Nash solution coincides with the reference point, the "index of tragedy" is 1. Therefore, the index of tragedy roughly describes t he "malignity" of a problem; as such, it has some similarity to our "regime potential": the more malign a problem is, the greater the potential benefits of an effective regime" (Helm & Sprinz, 2000).

Mitchell (2002), who contributes to establishing the numerical database of IEAs, is also interested on the quantitative modeling to evaluate the effectiveness of IEAs. He generates two regression models, which can be conveniently applied to the quantitative analysis, not only modeling to evaluate a single regime's effects but also modeling to compare regime's effects. He demonstrates that the variables that represent other influences on pollution have to be included for a more precise estimation. Therefore, as independent variables of a suggested regression model, the dummy variable MEMBER that reflects the effect of regime membership on emissions and other control variables are included as well. The conceptual model for SO_X emissions is as follows. In this equation, EMISS indicates annual emissions and POPN (population), COAL (coal usage), and EFFIC (energy efficiency) are included as the independent variables expected to have an effect on emissions. With the coefficient β_1, the effectiveness of IEAs can be represented in this conceptual model:

$$\text{EMISS} = \alpha + \beta_1 * \text{MEMBER} + \beta_2 * \text{POPN} + \beta_3 * \text{COAL} + \beta_4 * \text{EFFIC} + \cdots + \beta_N * \text{OTHER} + \epsilon$$

Second, for comparing regime's effects among various IEAs, a universal model have to be generated considering data availability. Hence, Mitchell (2002) generalizes the dependent variable in the previous equation as CRB, which represent "some annual measure of Change in Regulated Behavior under various treaties" (p. 64). The effectiveness variable, MEMBER, is also included in this model by the dummy variable, while other independent variables are changed into more generalized variables to make applicable variables from diverse IEAs. For example, CGNC and CPOP, which are the annual change in economic growth and population, are provided. Moreover, other control variables, such as SANCTION (the existence of sanctions), DEPTH (the depth of cooperation), and the interaction variables between MEMBER and SANCTION are included in his model:

$$\text{CRB} = \alpha + \beta_1 * \text{MEMBER} + \beta_2 * \text{SANCTION} + \beta_3 * \text{MEM-SANCT} + \beta_4 * \text{DEPTH} \\ + \beta_5 * \text{CGNP} + \beta_6 * \text{CPOP} + \beta_N * \text{OTHER} + \epsilon$$

CRB, which is an environmental performance data, can be collected from various data sources. To analyze the effectiveness of IEAs, two important tasks should be done. The first task is that the specific environmental problem or pollutant that is targeted in an IEA has to be found and matched with each IEA. Occasionally this is a hard task, since not all targets of IEAs are well exemplified in their article. After the matching process, reliable database about the target should be built as numerical data. However, it has been pointed out that the quality environmental performance data, such as short collecting period or limited collection object is not sufficient yet.

Even if more performance data for environmental indicators are suggested by

Mitchell in the hope page of IEA Database Project, but effectively adoptable as the numerical data for various countries are condensed. Note that, it is needed continuous efforts to establishing numerical environmental performance data for the quantitative analysis on the IEA effect on pollutant reduction. Table 2.7 suggests the possible examples of available numerical pollutants data and data source, which are determined conceivably possible to collect and cover relatively long periods.

Table 2.7 ***Available Pollutants Data and Source***

Item	Pollutant	Source
Air	Asbestos	Worldwide Asbestos Supply and Consumption Trends (Virta, 2006)
	CFCs	UNEP Ozone Secretariat (n.d.)
	SO_2	LRTAP Officially Reported Emission Data
	NO_X	(CEIP, n.d.)
	NMVOC	
	CO_2	World Development Indicators (WDI) (World Bank, n.d.)
Wastes	Hazardous waste	Basel Convention National reports (n.d.)
Species	Terrestrial and marine areas protected	Millennium Development Goal (MDG) Indicators (n.d.)
	Ratio of area protected to maintain biological diversity	
	Forest area	
Fishery	Aquaculture production	Food and Agriculture Organization of the United Nations (FAO) STAT (n.d.).
	Total fishery	

Source: Author.

Mitchell (2002)'s concrete examples raise a possibility of developments of quantitative analyses about the effectiveness of IEAs, even though research objects of these approaches are still limited in certain IEAs used to build the numerical database of targeted pollutants. Note that the quantitative analyses used to estimate the effectiveness of IEAs in the present thesis are also highly influenced by this approach.

To sum up, quantitative approaches for estimating effectiveness will be varied in accordance with perspectives emphasized in defining effectiveness. Thus, before discussing about the effectiveness of IEAs, it is necessary to define and narrow down the concept of the effectiveness of IEAs of this thesis.

2.5 The Effectiveness of IEAs for Sustainable Development

Among the numerous definitions and concepts of the effectiveness of IEAs, it is not a simple task to narrow the scope of the effectiveness for a specific analysis. Since this thesis intends to evaluate the effectiveness of IEAs from a broader perspective to suggest direction for improving IEAs for sustainable development, it is essential to consider the scope of IEAs within the perspective of sustainable development. As mentioned above, an IEA is a legal agreement for protecting environmental degradation and maintaining environment quality, thus there is no doubt that IEAs are closely associated with sustainable development (Kanie, 2007). In this context, this thesis regards IEAs as international environmental policies for the sustainable management of the global environment according to the stream of times that environmental issues are considered in the framework of sustainable development.

Here, another question arises. What is the sustainable management? The meaning of sustainable is broad but a lack of consensus, thus the definition of sustainability is diverse. Paterson (2008) also indicates that the meaning of sustainable is unclear but he demonstrates that "sustainability is nothing but green wash, an ideological smokescreen designed to mask the unsustainability of global capitalism" (p. 115). However, a lively discussion of the concept of sustainable development, sustainability has become accepted as "a change in a property referred to as 'system quality'" (Bell & Morse, 2008, p. 12). According to Bell and Morse (2008), "sustainable equates to a situation where quality remains the same or increases. If quality declines, then the system can be regarded as unsustainable" (p. 12). Figure 2.6 portrays this conception of sustainable and unsustainable in the relationship between time scale and system quality.

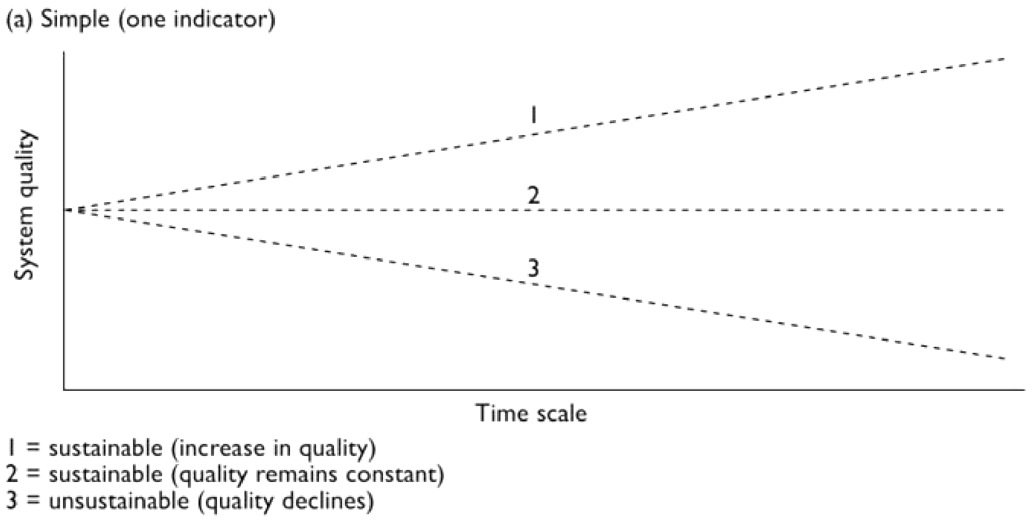

Figure 2.6 **System Quality and Sustainability**

Source: Bell and Morse (2008).

The term "sustainable development" was popularized in the Brundtland Commission, which is formally known as the World Commission on Environment and Development (WCED) (Adger & Jordan, 2009). The sustainable management of global environment concerns an interaction between nature and human system—in other words, between the global environment and development (Giddings et al., 2002; Redclift, 2005). Dietz and Neumayer (2008), who trace the origins of sustainable development, insist that optimal growth, in the viewpoint of economists, is not fully sustainable. Bell and Morse (2008) summarize the definitions of sustainability and sustainable development from major previous studies, as shown in Table 2.8.

Table 2.8 ***Definitions of Sustainability and Sustainable Development***

General definitions of sustainability include the following:
... The capacity of a system to maintain output at a level approximately equal to or greater than its historical average, with the approximation determined by the historical level of variability. (Lynam & Herdt, 1989)
... maximizing the net benefit of economic development, subject to maintaining the services and quality if natural resources over time. (Pearce & Turner, 1990)
The sustainability of natural ecosystems can be defined as the dynamic equilibrium between natural inputs and outputs, modified by external events such as climatic change and natural disasters. (Fresco & Kroonenberg, 1992)
Definitions of sustainable development:
... development that meets the needs of current generations without compromising the ability of future generation to meet their needs and aspirations. (WCED, 1987) *
... development that improves the quality of human life while living within the carry capacity of supporting ecosystems. (IUCN, 1991)**

Source: Bell and Morse (2008).
*Note. * is from Bruntland (1987) and ** is from Munro and Holdgate (1991) in the reference of this thesis.*

As introduced in Table 2.8, the WCED (1987) defines the classic definition of sustainable development as "meeting the needs of the present without compromising the ability of future generations to meet their needs" (p. 10). This concept combines socioeconomic concerns and environmental concerns that could come into conflict, and thus remains controversial.

In this context, it is true that the concept of sustainable development is connected with all the aspect of human beings lives. Consequently, it is necessary to decide how define a system for narrowing the scope of the concept of sustainable development. From the viewpoint of environmental policy for sustainable development, environment, economy, and society have to be considered.

In this respect, sustainable development is composed of the economy, environment and society, and these three sectors can be expressed as three interconnected rings (refer to Figure 2.7) (Barton, 2000; du Plessis, 2000; ICLEI, 1996). According to Adger and Jordan (2009), even though discussions of word sustainable development under the title “Our Common Future” brought the consciousness about common environmental problems in, synergies between the three elements of sustainable development have been the focus since the Brundtland Commission:

> The tile—Our Common Future—was deliberately chosen to emphasize that the world was suffering from common and interlinked problems, namely chronic poverty in the South and mounting social and environmental concerns in the North. Instead of talking about trade-off between the three pillars of sustainable development—society, and economy and the environment—after Brundtland, the search intensified for synergies between them. (p.8)

Even though there are debates about weaknesses and limitations of conceptual simplicity and doubt about relation and priority among sectors, the division of sustainable development into three separate sectors reveals the general approach to sustainable development (Giddings et al., 2002). Therefore, sustainability indicators (SIs) for estimating the degree of sustainability with a certain standards are generated based on three separate sectors stated above. For example, Appendix 2.3 introduces an example of a sustainable indicator the Norwich 21 set of Sis which is made based on UN Agenda 21.

From the effectiveness IEAs perspective, it is necessary to achieve the original purpose and enhance participation of IEAs considering the influence of IEAs on socioeconomic aspects of member countries. Especially, the effect of economic performance is practically important to vitalization IEAs through encouraging participation. More specifically, the reason is that imposing economic burden of IEAs caused by pollutant reduction is one of the significant considerations when countries decide whether to participate or not (Sprinz & Vaahtoranta, 1994). Moreover, it is expected to improve the efficiency of economic growth, especially in developing countries, since an environmental quality is closely related with the quality of human life—such as public health, life satisfaction, and even economic activities.

However, it is clear that there are scarcely studies but having analyzed the economic effectiveness of IEAs. Most previous studies have focused on the effect of IEAs on pollutant reduction (Aakvik & Tjøtta, 2011; Helm & Sprinz, 2000; Levy, 1993; Murdoch et al., 1997; Ringquist & Kostadinova, 2005; Vollenweider, 2013); in particular, quantitative analyses are concentrated on the environmental effectiveness despite relatively well-established economic databases.

In this respect, this thesis observes the effectiveness of IEAs not only in the environmental but also the economic aspect from the sustainable development point of view. Moreover, this thesis assumes that institutions, such as IEAs, can play an important role in balancing the environmental aspect and the economic aspects. From the investigation covering both sides of the effectiveness, it is expected that the current status of IEAs to date will be confirmed empirically and the requirements of IEAs for sustainable development can be elaborated. Figure 2.7 illustrates what dimensions are related to the effectiveness of IEAs from the viewpoint of sustainable development and clarifies the research scope of this thesis. More specific discussions about each area—the environmental and economic effectiveness—are provided in the following sections.

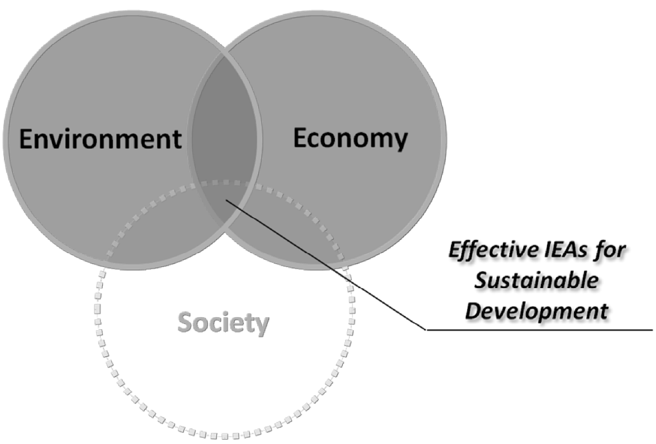

Figure 2.7 **Role of IEAs for Sustainable Development.**

Source: Author.

2.5.1 Environmental Effectiveness of IEAs. IEAs are international environmental policies which results from an actual need for solving environmental problems across nations. Therefore, when scholars estimate the effectiveness of IEAs, the environmental effectiveness, which is identified by the improvement of environmental performance, primary receives attention. However, the effectiveness of the IEAs on pollutant reduction is still questioned owing to endemic characteristic of international institutions.

Most IEAs are soft institutions that are socially important but non-legally binding instruments. Primarily, IEAs place priority on initiating and maintaining the international instrument considering differences in national environmental circumstance, society-economic situation, and cultural diversity (Dupuy, 1990). Therefore, by imposing voluntary and flexible obligations, an atmosphere of international cooperation is promoted. Lidskog and Sundqvist (2002) indicate that since most international regimes fail to adopt a sanction mechanism and the successful implementation is also limited, it is difficult to figure out whether international environmental regimes are effective in international cooperation. Since then, more specific and compulsory provisions are discussed and appended as a form of amendment or other auditory agreements.

To achieve the goal of IEAs that is pollutant reduction, the realistic and effective linkages between international environmental policies and the domestic environmental policies is an essential prerequisite. According to Ringquist and Kostadinova (2005), the effective domestic environmental policy needs three elements and participating in IEAs have an effect on these elements: 1) increased governmental concern regarding the issue, 2) a hospitable contractual environment emphasizing monitoring and credible commitments, 3) the governing capacity necessary to change policy. There is an optimistic point of view about this relationship. For example, Helm (1998) demonstrates that IEAs promote cooperative behaviors and political decision making as means to interpret scientific uncertainties.

On the other hand, there also exist scholars who cast doubt on the positive influence of IEAs and insist that there are gaps between international environmental policies and national environmental policies. As a result of the characteristic of soft institution, they are usually formally autonomous from the domestic policy or law. Buttel (2000) indicates that IEAs have their weakest impact on national environmental performance because international agreements do not dictate to the policy implementation of each nation. As Mearsheimer (1994) demonstrates, there is a possibility in international institutions that some countries get a free ride in terms of pollutant reduction. Moreover, nations can avoid the economic costs by treating IEA as a kind of ceremonial behavior—that is, they are entered into in spirit but not in deed (Meyer & Rowan, 1977). Harner-Burton and Tsutsui (2005) designate this phenomenon as the “paradox of empty promise”. Another trigger of this problem is originated from lack national capacity. Even if a country feels the need to protect the environment and join IEAs, if they are not capable of substantive policy implementation, it is difficult for the

IEA to cause actual environmental improvement. Therefore, Zürn (1998) indicates that even though various case studies about the regime effectiveness are conducted, systematic research on regime effects is not sufficiently complete:

> Do regimes matter? In the meantime, the evidence accumulated by various case studies should have settled the matter. But even if these studies have convincingly shown that regimes often do make a difference in one way or another, they are still no substitute for systematic research on regime effects. And research on environmental regimes has, in fact, generated a dramatic increase in interest in these questions. (p. 632)

Majority of quantitative studies about the environmental effectiveness of IEAs have usually estimated the effectiveness of IEAs from an "impact" perspective that estimates the effectiveness of eliminating or reducing pollutants (Hisschemöller & Gupta, 1999; Mitchell, 2002). Therefore, the effectiveness of IEAs is usually estimated in terms of whether environmental performance of member countries is improved (Mitchell, 2004; Young, 1999). This coincides with a "problem solving approach" of Young (1999), with which it is possible to obtain data sets on changes in environmental quality. This approach is in line with the OPS for measuring regime effectiveness (Helm & Sprinz, 2000), which "[r]ather than focusing on behavioral change, OPS assesses regimes effectiveness by way of regime-caused improvements of the state of a problem" (Sprinz & Kaan, 2006, p. 8). Mitchell (2008) also makes clear that impact indicators can reflect environmental quality targets of IEAs. Additionally, quantitative approaches complement the weaknesses of qualitative approaches, as they grasp causal relationships between IEAs and environmental performance, and it is possible to compare various IEAs simultaneously by means of numerical data (Mitchell & Bernauer, 1998).

Moreover, appropriate models and data sets for analyzing the effectiveness of IEAs have been constantly under consideration. Mitchell (2004) argues that quantitative approach can answer about the questions about regime effectiveness with "careful modeling" and analysis of "appropriate data". Scholars have tried to make analysis robust. However, due to a scarcity of data and existence of non-random process, analysis of the practical effectiveness of IEAs has many limitations. Ringquist and Kostadinova (2005) also clarify why assessing the effectiveness of IEAs is difficult:

> To be sure, evaluating the effectiveness of international agreements faces several formidable obstacles. First, many of these agreements are so recent that estimating their effects is premature, while consistent and reliable data for estimating the effects of older agreements are difficult to obtain. Second, indicators of environmental quality are affected by a host of factors independent of these agreements. Finally, the overwhelming majority of IEAs are characterized by voluntary participation, which means that any evaluation must generate measures of program effectiveness from a

self-selected sample—a notoriously difficult proposition. (p. 86)

Fortunately, lager and more detailed databases have been developed, and statistic methodologies have become more accurate in recent analyses. Therefore, further research should broaden research objects and models to grasp the practical effectiveness of IEAs more clearly. The representative database about IEAs has been established by Mitchell (Mitchell, 2013) who is introduced in Section 2.2. Note that the present thesis also refers to this database to investigate the status of participation of each regime and proper environmental data. Table 2.9 shows information about IEAs that Mitchell (2013) intends to provide. Not only basic information about IEAs but also performance data is contained in this database.

Table 2.9 ***Information Provided by Mitchell's Database***

- A truly systematic, comprehensive and up to date list (i.e., the population) of multilateral environmental agreements (MEAs) –plans are for the database to be updated at least every 6 months
- An extensive (but necessarily incomplete) list of bilateral (BEAs) and other environmental agreements
- Basic information on each agreement (signature date, place of signature, entry into force date, members, responsible secretariat, etc.)
- The electronic texts (fully searchable) for all MEAs and a range of BEAs, including the original, as well as the current ("as amended"), versions of the texts
- Coded versions of a subset of MEAs that allow systematic comparison of agreement features;
- Access to an extensive repository of "performance data" that can be used to assess institutional influence on state behavior

Source: Mitchell (2013).

However, even though databases of IEAs have been developed in line with an increasing number of IEAs, associated quantitative analyses have been lacking. Because of data limitations and a lack of sufficient analysis period, the majority of previous studies about practical effectiveness of IEAs have focused on particular pollutants, especially SO_X and NO_X of the LRTAP regime (Aakvik & Tjøtta, 2011; Helm & Sprinz, 2000; Levy, 1993; Murdoch et al., 1997; Ringquist & Kostadinova, 2005; Vollenweider, 2013). The reason is that the history of LRTAP is relatively long, and comparative research is possible due to the existence of several protocols[9] (Wettestad, 1997). However, it is obvious that their research results about the practical effectiveness of IEAs remain controversial.

Most of all, the Helsinki and Sofia Protocols, which are established to reduce SO_X and NO_X emissions, respectively, are investigated relatively frequently. Levy (1993) tries to estimate the effectiveness on emission reduction with quantitative perspective. His method is relatively simple than quantitative analyses in recent articles, but a significant SO_X emission reduction is proved with comparing forecast emissions and actual emissions. Murdoch et al. (1997) investigate the effectiveness of LRTAP using both the Helsinki and Sofia Protocols. They demonstrate that only the Helsinki Protocol has a statistically significant effect on emission reductions, while the Sofia Protocols is not robust.

There is a movement to generate a general model for evaluate the effectiveness of

[9] This tendency is also observed in the qualitative analysis about IEAs.

IEAs. For example, Helm and Sprinz (2000) provide a systematic tool (refer to Figure 2.5) and determine a significant emission reduction by both the Helsinki and Sofia Protocols. In the analysis of Ringquist and Kostadinova (2005), the Helsinki Protocol is not found as effective when they apply a non-random process. Moreover, Aakvik and Tjøtta (2011) conduct the DID estimation to control for non-random process, and observe no significant effect on reducing emissions for either the Helsinki Protocol or the Oslo Protocol. Likewise, Vollenweider (2013), who is the most recent empirical analysis of the effectiveness of LRTAP, investigates the effectiveness in changing member states' behavior with emissions of NO_X and SO_2 using the DID model. The result also indicates that participating in LRTAP had no significant effect on state behavior of neither NO_X nor SO_2 emissions. More specific information about previous studies on LRTAP protocols is introduced in Chapter 3.

Note that there are strong needs to analyze not only particular IEAs but also IEAs per se, since research results within particular IEAs are easily biased. Although this section does not contain all of previous studies, it is true that a higher number of previous studies deal with particular regimes and countries, such as the effect of the Helsinki Protocol in Europe. Therefore, evaluating the overall effectiveness of IEAs is quite difficult. Tanaka and Matsuoka (2010) also point out limitations of previous studies. They argue that it is difficult to perceive overall effectiveness of IEA from analysis just focusing on a single particular treaty. Mitchell (2003), who summarizes previous studies and discusses about the effectiveness of IEAs, also points out the limitations of existing analyses as follows:

> A summary of existing analyses clarifies (a) that major obstacles exist to analyzing agreement effects accurately, (b) that only a relatively small subset of agreements have been analyzed, (c) that data exists on a significantly broader range of agreements, and (d) that more careful and systematic comparison of IEA effects is needed. (p. 446)

Furthermore, it is pointed out that there is a need to investigate more quantitative research on the effectiveness of IEAs in various regions. Most previous studies have been conducted on western countries, on Europe in particular (Aakvik & Tjøtta, 2011; Helm & Sprinz, 2000; Murdoch et al., 1997; Ringquist & Kostadinova, 2005; Vollenweider, 2013). However, there is a possibility that differences on regional environmental situations and the effectiveness of IEAs can be observed. In this regard, broader research on various regions is needed to identify the problems and solutions of environmental cooperation, providing a firmer foundation for future sustainable development.

In summary, most quantitative analyses of the environmental effectiveness of IEAs have focused on the changing pollutants because it is possible to obtain data sets on changes in environmental quality (for example, changes in SO_X emissions). In this sense, "environmental effectiveness" can be perceived through the problem-solving approach which involves the effect of IEAs in terms of eliminating or reducing environmental problems.

Therefore, each nation's environmental performance of targeted pollutants of IEAs is used for the environmental effectiveness of this thesis. This thesis intends to carry out the quantitative analysis for investigating the environmental effectiveness of IEAs with more diverse cases and data.

2.5.2 Economic Effectiveness of IEAs. As mentioned in Section 2.5.1, both the environmental and the economic effect of IEAs are significant considerations when a country decides whether they participate in the IEA, and it cannot be overlooked from the perspective of sustainable development. Indeed, many countries, especially developing countries, pay careful attention to the expected negative effect on the economic growth. As mentioned in the previous sections, economic burden by reducing pollutants causes the free rider problem, which decreases the overall effectiveness of IEAs (Mearsheimer, 1994). Kanie (2007) also states that the economic burden is considerable even in developed countries: "Public expenditures on environmental protection and sustainable development in the advanced industrialized countries now routinely run between 2–3% of their GNP" (p. 71). Accordingly, the IEAs could be degraded to the "empty promise" (Harner-Burton & Tsutsui, 2005; Meyer & Rowan, 1977). From this point of view, a necessity of considering the effect on the economy of participants has come to the fore. For example, the Kyoto Protocol only places a reduction burdens on developed nations, which means developing nations are not legally obliged to reduce CO_2 emissions.

Nevertheless, it is true that there is scarcely any study has considered economic performance of the participants along with the environmental effectiveness. Moreover, few studies have analyzed the economic effectiveness of IEAs (Golub et al., 2006; Manne & Richels, 1998). For example, Golub et al. (2006) investigate climate change costs with previous studies on short-term cost models and long-term models, and examines the estimates of the costs of the Kyoto Protocol for the United States. However, previous studies have focused on a simple comparison and there are observed methodological limitations. Therefore, more practical and precise analysis on the economic effectiveness of IEAs was needed for making a rational decision instead of vague concerns about the negative effect.

Notwithstanding these shortcomings, there is theoretical evidence, such as the "Porter Hypothesis", that supports the supposition that IEA improves both environmental and economic performance through enhancing innovation and, thus, greater economic efficiency (Esty & Porter, 2001; Golub et al., 2006; Lanoie et al., 2011; Lindmark, 2002; Manne & Richels, 1998; Porter & van der Linde, 1995). Porter and van der Linde (1995) introduce the Porter Hypothesis as follows:

> Our central message is that the environment-competitiveness debate has been framed incorrectly. The notion of an inevitable struggle between ecology and the economy grows out of a static view of environmental regulation, in which technology,

products, processes and customer needs are all fixed. In this static world, where firms have already made their cost-minimizing choices, environmental regulation inevitably raises costs and will tend to reduce the market share of domestic companies on global markets. However, the paradigm defining competitiveness has been shifting, particularly in the last 20 to 30 years, away from this static model. The new paradigm of inter-national competitiveness is a dynamic one, based on innovation. (p. 97)

Even though this hypothesis is established in the domestic perspective, it is apparent that the possibility of apply this concept to the international level is not outrageous. In particular, since the Kyoto Protocol was established based on market-based mechanisms, it seems to be more appropriate to apply this assumption into the effectiveness IEAs. In this sense, The Porter Hypothesis provides a clue of theoretical potential that the environmental effectiveness of IEAs can be connected to the economic effectiveness.

Unlike traditional view point that environmental policies have a negative effect on the productivity, Porter and van der Linde (1995) argue that more stringent and flexible environmental policies improve both environmental and economic performance by leading innovations to improve environmental performance and redress inefficiencies. That is, technological advances caused by environmental policies can induce economic development, as demonstrated in Figure 2.8 (Lanoie et al., 2011).

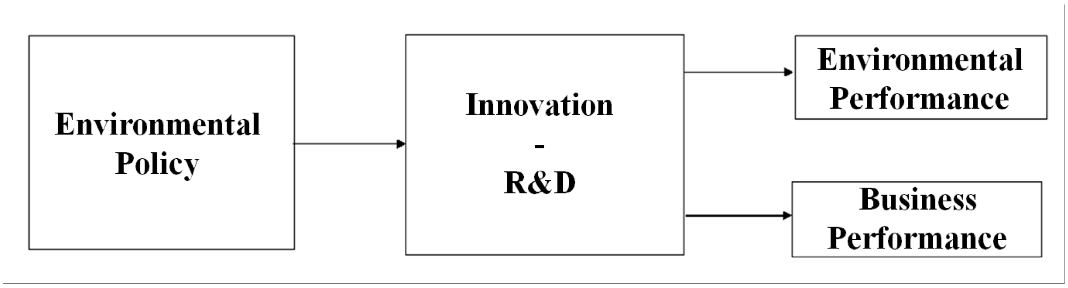

Figure 2.8 **Porter Hypothesis**

Source: Author, based on Lanoie et al. (2011).

Esty and Porter (2001) conduct an analysis on national comparison and perceive that the quality of environmental policy is highly and positively correlated with the competitiveness of a nation. Moreover, the Porter Hypothesis is related to the production function because economic performance improvement caused by innovations is included in Total Factor Productivity (TFP). Tzouvelekas, Vouvaki and Xepapadeas (2007) insist that Green Total Factor Productivity (GTFP) contains general technological progress and technological progress related to emission reduction. However, in their empirical analysis, it is difficult to extract only technological progress related to emission reduction.

As mentioned above, even though the Porter Hypothesis was originally established upon a national economic circumstance based upon a market-based instrument, this theory provides inspiration to expended approaches for evaluating the effectiveness of IEAs. Figure 2.9 depicts the conceptual framework for applying the Porter Hypothesis with IEAs based on Figure 2.8 by Lanoie et al. (2011) above.

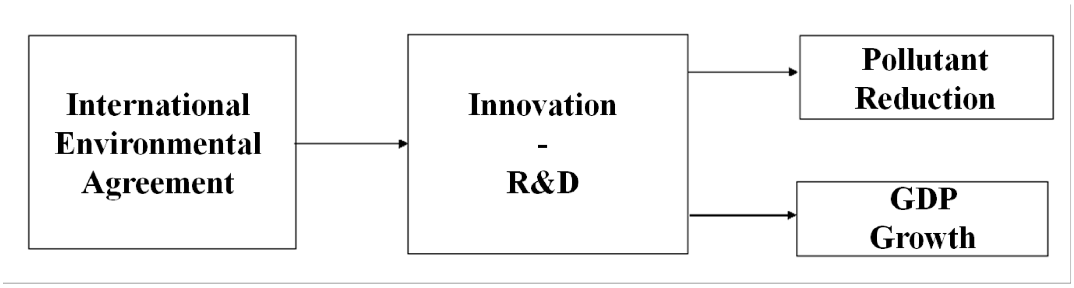

Figure 2.9 **Porter Hypothesis Application for IEAs**

Source: Author.

Note that no empirical study about the synergy effect between the environmental policies and economic performance was conducted with the IEAs. Therefore, this thesis examines the effect of IEAs on economy of member countries. If the Porter Hypothesis is valid in IEAs, participating in IEAs triggers innovations of member countries in line with investment in R&D. As a result, a positive effect on pollutant reduction and economic growth can be achieved by IEAs.

To evaluate the economic effectiveness of IEAs in quantitative ways, it is necessary to find the proxy for assessing the economic situation of participants and non-participants of IEAs. Based on the literatures, such as the environmental Kuznets curve (EKC)[10] and Gross Domestic Product (GDP) of each nation, is used for the dependent variables for estimating the economic effectiveness of IEAs in all the main chapters of this thesis. More specifics

[10] Kuznets Curve diagrams have inequality on the Y-axis, economic development on the X-axis, and an inverted U-curve. This theory indicates that economic inequality increases until a certain point is attained, after which it begins to decrease. This theory has been adopted in the environmental sector, thereby implying that pollution increases until a certain stage of economic development; when a country reaches this point, thereafter its environmental performance improves.

about the proxy variables will be provided in each main chapter.

2.6 Conditions for the Effective IEAs

Most previous quantitative studies on the effectiveness of IEAs are concerned with the practical effectiveness of the IEA itself. These studies have demonstrated the effectiveness of IEAs on the reduction of environmental pollution, and a majority of these studies have argued that IEAs are effective. However, previous studies on the conditions of effective IEAs are limited. Therefore, the question that must be asked is, what elements make IEAs effective?

First, regime elements have influence on the effectiveness of IEAs. Böhmelt and Pilster (2010) evaluate the influence of two regime elements—legalization and flexibility—on the effectiveness of 23 international environmental regimes. They define legalization as "a system of institutionalised rules, norms and regulations that characterize regimes along three dimensions" (p. 248) and measure obligation, precision, and the impact of delegation. Furthermore, flexibility is defined as "procedural opportunities for transcending initial constraints" (p. 249). Flexibility of regime bodies, impact of different categories for regime members, decision-making rules and flexible agendas are included as the flexibility variables. The variables that represent legalization and flexibility of regimes are used from the IRD (Breitmeier et al., 2006). The results indicate that precision had a positive influence on regime effectiveness and that flexibility in regime bodies makes regimes more effective.

Moreover, Tanaka and Matsuoka (2010) investigate conditions that affect the effectiveness of IEAs using treaty-level panel data. They analyze both the fixed-effect and random-effect models using panel data for 14 IEAs. In their empirical model, one group of variables is “a matrix of explanatory variables regarding the attributes of treaty” (Tanaka & Matsuoka, 2010), which represents conditions of effective IEAs. This variable contains four explanatory variables: sanction procedures, considerations for developing countries and two mechanisms of assistance—financial assistance and technical assistance—for developing countries. Unlike Böhmelt and Pilster (2010), who use regime data from the IRD, multiplying and standardizing original variables, Tanaka and Matsuoka (2010) use data on the changes in actual environmental performance. The main finding of this study is that sanctions for non-compliance and financial assistance have positive effects, while technical assistance is not significant.

Second, not only regime elements but also diverse environmental problems of IEAs can make a difference to the effectiveness of IEAs. Matsuoka et al. (1998), who categorize pollutants by countries’ social and economic character, have noted that there are several types of pollutants. They assert that SO_X is applicable to the EKC[11], while it is difficult to get a satisfying result with NO_X and CO_2. Moreover, green type, such as forest resources protection, is greatly influenced by social factors, such as population, rather than economic situations. Matsuoka (2004) insists that pollutants can be classified under three types by the relationship with economic growth. Figure 2.10 presents the relationship between types of pollutants and economic growth. In case of the public health and the water, pollution is in inverse proportion to economic growth; on the other hand, CO_2 and waste are direct proportion. SO_2 and suspended particulate matter (SPM) show the inverted U relationship. Therefore, establishing policies with deliberating characteristic of pollutants is also needed to enhance policy effect of IEAs.

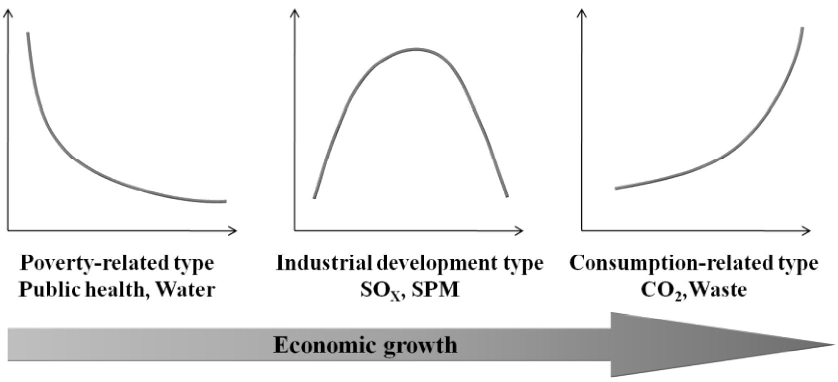

Figure 2.10 **Types of Pollutants and Economic Growth**

Source: Matsuoka (2004), based on Bai et al. (2000).

[11] EKC is the inverted U relationship between income change and environmental quality. "Degradation increases with wealth until at a certain point degradation lessens. This could be due to closure of polluting companies (or relocation) and the introduction of new methods of production and technologies to lessen pollution" (Bell & Morse, 2008).

To sum up, in order to make IEAs more effective, it is crucial to understand which conditions make IEAs effective. However, studies on the conditions of effective IEAs are still in their initial stages; thus, it is difficult to find previous studies on this subject. More research on the conditions of effective IEAs is required. In this context, this thesis also focused on this aspect mainly in Chapter 5 with various IEAs to answer the research question: *Which regime elements of IEAs have a beneficial effect on the environmental and economic performance of member countries?* Since Chapter 3 and Chapter 4 conduct the quantitative analyses using various IEAs targeting difference pollutants, Chapter 5 focuses on the regime elements categorized as legalization and flexibility, and provides empirical evidence about how those elements affect the effectiveness of IEAs.

2.7 Achievements and Limitations of Existing Studies

IEAs are the one of the representative international institutional instruments for coping with global environmental degradation. In line with the increasing need for analyzing and evaluating the effectiveness of IEAs for the further sustainable development, scholars' interest in the effectiveness of IEAs has increased. Even though there are not yet sufficient studies, achievements of the existing studies have paved the way for the further research on the effectiveness of IEAs.

Studies about IEAs have established various aspects of the effectiveness of IEAs

(Karlsson-Vinkhuyzen & Sylvia, 2009; Miles et al., 2002; Mitchell, 2008; Young, 1999) and giving the evidence of quantitative analysis of the effectiveness of IEAs (Mitchell, 2004, 2008). Based on this process, there also exist quantitative analyses on particular pollutants, especially in the context of LRTAP (Aakvik & Tjøtta, 2011; Helm & Sprinz, 2000; Levy, 1993; Murdoch et al., 1997; Ringquist & Kostadinova, 2005; Vollenweider, 2013).

On the other hand, some limitations of previous studies on the effectiveness of IEAs are also observed. First, many quantitative studies bring controversial results because of persistent self-interested characteristic of IEAs. The principal reason is perceived that most previous studies fail to grasp the effect of IEAs controlling for external factors of each nation, such as emission trends. To measure the effectiveness of IEAs precisely, it is necessary to evaluate the effectiveness of existing IEAs with more accurate methodologies that control for these factors. However, diverse characteristic of pollutants and a scarcity of data and limitations of methodologies for evaluating the effectiveness of IEAs led to unreliable results of previous studies.

Second, there are not yet sufficient research objects using quantitative analysis of the effectiveness of IEAs. According to the impact evaluation method, objective long-term data including before and after program is required in order to evaluate the effectiveness of a certain program accurately. However, due to difficulties of collecting data and a lack of objective long-term data before and after the IEA, previous studies, which intend to measure the effectiveness of IEAs, are concentrated on specific IEAs, such as the protocols of LRTAP, where the numerical environmental performance data is easier to obtain and is also relatively longer (temporally) than other IEAs.

Finally, that evaluating the economic effectiveness of IEAs to contribute to future sustainable development is required, since the mainstream literature has focused on the effectiveness of IEAs on reducing pollutants. Even if the main purpose of IEAs is to prevent environmental degradation and reduction by promoting cooperation in environmental issues, the economic impact of each country cannot be ignored for continuous development of IEAs. As discussed above, the economic burden caused by pollutants IEAs is one of the significant considerations when countries decide whether to participate in IEAs (Sprinz & Vaahtoranta, 1994). Nevertheless, it is difficult to find previous research that directly focuses on the effect of participating in IEAs on economic performance of member countries.

In this context, the contribution of this thesis is to redress the academic uncertainty of previous studies with advanced quantitative method. Utilizing the impact evaluation methodologies with considering the average differences in emissions and the characteristics of each nation for participants and non-participants over the periods, this thesis could investigate the effectiveness of IEAs more precisely. Furthermore, this thesis embraces not only the environmental effectiveness but also the economic effectiveness in all analyses, with two cases selected under the notion of common responsibility and common but differentiated responsibility. Finally, this study uniquely evaluates causality between regime elements of IEAs and environmental and economic effectiveness with various IEAs data.

Appendix 2.1 Annual Count of MEA in the IEA Database: 1857–2012

Year	Agreements	Protocols	Amendments	Other modifications	Total	Cum. Total
1857	1	0	0	0	1	1
1868	0	0	1	0	1	2
1877	1	0	0	0	1	3
1878	1	0	0	0	1	4
1879	0	0	1	0	1	5
1881	1	0	0	0	1	6
1882	1	0	0	0	1	7
1884	1	2	0	0	3	10
1885	2	1	0	0	3	13
1887	3	0	0	0	3	16
1889	0	0	1	0	1	17
1893	2	1	0	0	3	20
1897	2	0	0	0	2	22
1899	0	0	1	0	1	23
1900	2	0	0	0	2	25
1902	2	0	0	0	2	27
1905	1	0	0	0	1	28
1909	2	0	0	0	2	30
1911	1	0	0	0	1	31
1913	2	0	0	0	2	33
1919	1	0	0	0	1	34
1920	2	1	0	0	3	37
1921	1	0	0	0	1	38
1922	1	0	0	0	1	39
1923	1	1	0	0	2	41
1924	1	0	0	0	1	42
1925	0	1	0	0	1	43
1926	1	0	0	0	1	44
1929	2	0	0	0	2	46
1930	0	0	1	0	1	47
1931	1	0	0	0	1	48
1932	1	0	0	0	1	49
1933	1	1	0	0	2	51

1934	1	0	0	0	1	52
1935	3	0	0	0	3	55
1937	3	0	0	0	3	58
1938	0	1	1	0	2	60
1940	1	0	0	0	1	61
1941	1	0	0	0	1	62
1942	1	0	0	0	1	63
1944	1	1	0	0	2	65
1945	1	2	0	0	3	68
1946	2	2	0	0	4	72
1947	0	1	0	0	1	73
1948	1	0	0	0	1	74
1949	4	0	2	0	6	80
1950	1	1	1	0	3	83
1951	2	0	1	0	3	86
1952	6	1	3	0	10	96
1953	2	1	2	0	5	101
1954	8	0	1	0	9	110
1955	2	0	3	0	5	115
1956	2	3	1	0	6	121
1957	3	0	3	0	6	127
1958	4	2	4	0	10	137
1959	8	1	2	0	11	148
1960	4	0	2	0	6	154
1961	1	2	4	0	7	161
1962	6	1	6	0	13	174
1963	9	4	4	0	17	191
1964	9	3	1	0	13	204
1965	3	2	2	0	7	211
1966	5	1	2	0	8	219
1967	7	2	3	1	13	232
1968	6	1	4	0	11	243
1969	8	1	3	0	12	255
1970	4	2	3	0	9	264
1971	6	0	3	0	9	273
1972	11	1	4	0	16	289
1973	9	3	4	0	16	305

1974	6	1	1	0	8	313
1975	1	1	3	0	5	318
1976	12	6	4	0	22	340
1977	8	1	7	0	16	356
1978	7	8	8	0	23	379
1979	9	1	9	0	19	398
1980	6	3	4	0	13	411
1981	4	1	10	0	15	426
1982	8	5	3	0	16	442
1983	7	9	8	0	24	466
1984	4	5	5	0	14	480
1985	8	3	9	0	20	500
1986	7	6	4	0	17	517
1987	9	3	10	0	22	539
1988	2	2	4	0	8	547
1989	10	4	11	0	25	572
1990	10	6	11	0	27	599
1991	16	5	15	0	36	635
1992	25	11	17	0	53	688
1993	22	1	11	0	34	722
1994	22	7	12	0	41	763
1995	9	5	14	0	28	791
1996	10	9	12	0	31	822
1997	12	3	17	0	32	854
1998	16	10	12	0	38	892
1999	8	10	16	0	34	926
2000	7	6	17	0	30	956
2001	12	1	12	0	25	981
2002	12	7	15	0	34	1015
2003	11	7	9	0	27	1042
2004	5	4	19	0	28	1070
2005	4	2	10	0	16	1086
2006	6	1	15	0	22	1108
2007	4	0	12	0	16	1124
2008	2	3	5	0	10	1134
2009	5	3	13	0	21	1155
2010	4	5	8	0	17	1172

2011	1	3	10	0	14	1186
2012	1	1	12	0	14	1200

Source: Mitchell (2013).

Appendix 2.2 Annual Count of BEA in the IEA Database: 1802–2012

Year	Agreements	Protocols	Amendments	Other modifications	Total	Cum. Total
1802	1	0	0	0	1	1
1814	1	0	0	0	1	2
1815	2	0	0	0	2	4
1818	1	0	0	0	1	5
1824	1	0	0	0	1	6
1825	1	0	0	0	1	7
1826	2	0	0	0	2	9
1827	1	0	0	0	1	10
1831	1	0	0	0	1	11
1834	1	0	0	0	1	12
1839	3	0	0	0	3	15
1843	4	0	0	0	4	19
1845	1	0	0	0	1	20
1854	1	0	0	0	1	21
1857	1	0	0	0	1	22
1858	1	0	0	0	1	23
1859	1	0	0	0	1	24
1863	1	0	0	0	1	25
1867	1	0	0	0	1	26
1869	1	0	0	0	1	27
1870	1	0	0	0	1	28
1871	2	0	0	0	2	30
1873	1	0	0	0	1	31
1875	1	0	0	0	1	32
1878	2	0	0	1	3	35
1880	2	0	0	0	2	37
1881	1	0	0	0	1	38
1882	2	1	0	0	3	41
1883	3	0	0	0	3	44
1884	2	0	1	0	3	47
1885	2	0	0	0	2	49
1886	1	0	0	0	1	50
1887	1	0	0	0	1	51

1888	0	1	0	0	1	52
1891	5	0	0	0	5	57
1892	3	0	1	0	4	61
1893	2	0	0	0	2	63
1894	1	0	0	0	1	64
1896	1	0	0	0	1	65
1897	3	0	0	0	3	68
1899	1	0	0	0	1	69
1901	3	0	0	0	3	72
1902	2	0	0	0	2	74
1903	1	0	0	0	1	75
1904	2	0	0	0	2	77
1905	1	0	0	0	1	78
1906	5	0	0	0	5	83
1907	4	0	0	0	4	87
1908	3	0	0	0	3	90
1909	2	0	0	0	2	92
1911	1	0	0	0	1	93
1912	3	0	0	0	3	96
1913	2	0	0	0	2	98
1914	1	0	0	0	1	99
1916	2	0	0	0	2	101
1920	0	0	1	0	1	102
1921	2	0	0	0	2	104
1922	11	0	0	0	11	115
1923	2	0	0	0	2	117
1924	2	0	0	0	2	119
1925	7	3	0	0	10	129
1926	4	0	1	0	5	134
1927	4	0	0	0	4	138
1928	4	0	0	0	4	142
1929	1	0	0	0	1	143
1930	4	0	0	0	4	147
1931	3	0	0	0	3	150
1932	3	0	0	0	3	153
1933	2	1	0	0	3	156
1934	3	0	0	0	3	159

1935	5	0	0	0	5	164
1936	1	0	0	0	1	165
1937	1	1	0	0	2	167
1938	5	0	0	0	5	172
1939	1	0	0	0	1	173
1940	2	0	0	0	2	175
1941	2	0	0	0	2	177
1942	1	0	0	1	2	179
1944	5	1	0	0	6	185
1945	1	0	0	0	1	186
1946	1	0	0	0	1	187
1947	2	0	1	0	3	190
1948	3	0	0	0	3	193
1949	5	0	0	0	5	198
1950	9	0	0	0	9	207
1951	3	0	0	0	3	210
1952	6	0	1	0	7	217
1953	5	0	0	0	5	222
1954	8	1	0	1	10	232
1955	8	1	0	0	9	241
1956	12	2	0	0	14	255
1957	10	0	0	1	11	266
1958	12	1	0	0	13	279
1959	13	1	0	1	15	294
1960	9	1	1	0	11	305
1961	15	1	0	0	16	321
1962	7	2	0	0	9	330
1963	8	1	0	0	9	339
1964	14	0	0	5	19	358
1965	11	1	0	0	12	370
1966	15	0	0	1	16	386
1967	24	1	3	0	28	414
1968	16	0	2	2	20	434
1969	19	0	1	1	21	455
1970	12	0	1	1	14	469
1971	29	1	1	0	31	500
1972	31	0	4	2	37	537

1973	35	2	2	1	40	577
1974	31	1	4	2	38	615
1975	49	1	6	0	56	671
1976	42	2	1	0	45	716
1977	44	1	2	1	48	764
1978	32	1	1	0	34	798
1979	18	3	0	0	21	819
1980	15	1	1	0	17	836
1981	12	1	0	0	13	849
1982	9	2	1	0	12	861
1983	12	1	1	0	14	875
1984	13	1	1	0	15	890
1985	14	0	0	1	15	905
1986	15	0	2	2	19	924
1987	26	2	1	0	29	953
1988	13	3	0	1	17	970
1989	15	0	0	2	17	987
1990	32	1	0	2	35	1022
1991	31	0	0	1	32	1054
1992	40	0	1	0	41	1095
1993	46	1	0	1	48	1143
1994	58	1	0	1	60	1203
1995	52	3	2	3	60	1263
1996	45	1	0	0	46	1309
1997	55	8	1	0	64	1373
1998	54	1	0	1	56	1429
1999	32	1	0	1	34	1463
2000	27	1	0	2	30	1493
2001	17	0	0	0	17	1510
2002	10	1	0	0	11	1521
2003	1	0	0	0	1	1522
2004	3	0	0	0	3	1525
2005	2	0	0	0	2	1527
2006	10	0	1	0	11	1538
2007	1	1	0	0	2	1540
2008	10	0	0	0	10	1550
2009	4	1	0	0	5	1555

2010	12	0	0	0	12	1567
2011	4	1	0	0	5	1572
2012	0	1	0	0	1	1573

Source: Mitchell (2013).

Appendix 2.3 The Norwich 21 Set of SIs

SI	Notes	Target	UN chapter
Environmental protection			
1 Clean air	Number of days of good air quality	Increase	9
2 Less domestic waste	Tonnes of waste produced per household; total domestic waste recycled	Decrease Increase	21
3 Saving water	Cubic metres of water consumed by all users in a year	Decrease	18
4 Saving energy	Energy (gas and electricity) consumed by domestic and industrial users per year	Decrease	4
5 Clean river water	Quality of water in the two main rivers in Norwich (dissolved oxygen, BOD, ammonia)	Increase	18
6 More wildlife	Number of swans living and breeding on the two main rivers in Norwich	Increase	15
7 Protecting open spaces	Area of green field sites developed within the Norwich area	Increase	
8 Clean streets	Amount of litter on the streets	Decrease	7
9 Less traffic	Number of trips each year by:		
	• cars	Increase	
	• public transport	Increase	
	• cycle	Increase	
	• foot	Increase	
10 Safer streets	Length of streets that are fully pedestrianized and traffic calmed	Increase	
Economic development			
11 Less unemployment	Unemployment rate	Decrease	3
12 More skilled people	Percentage of the population achieving national training and education targets	Increase	12
13 More jobs	Net increase in number of jobs	Increase	3
14 Regional capital for business	Number of medium to large firms with regional or national headquarters in Norwich	Increase	
15 More money from tourism	Number of overnight stays by visitors in hotels	Increase	
Social development			
16 Less poverty	Percentage of the population living at or below the	Decrease	3

	poverty line		
17 Reduced housing problems	The number of: • homeless people • people in need of specialist accommodation • people in overcrowded accommodation	 Decrease Decrease Decrease	7
18 Improved local services	Number of people who live within walking distance of a centre of local services	Increase	
19 More people involved in local democracy	Percentage of eligible people voting in local elections	Increase	
20 More sports facilities	Number of sports facilities as measured against English Sports Council targets	Increase	
21 A safer city	The level of reported crime (domestic violence and burglary; non-domestic violence)	Decrease	
22 More arts and culture	Number of seats/venues (cinema, theatre, etc.)	Increase	
23 Maintaining our heritage	Number of listed buildings; number of collections/museums open to the public	Maintain Increase	

Source: Policy Unit, Norwich City Council, City Hall, Norwich adopted from Bell and Morse (2008).

CHAPTER 3

Environmental Effectiveness and Economic Burden of IEAs: The Case of LRTAP

This chapter aims to empirically investigate research questions about the environmental and economic effectiveness of IEAs with four LRTAP protocols (the Helsinki, Sofia, Oslo, and Geneva Protocols). The effectiveness of LRTAP is examined by the impact evaluation method which combines the DID method with the PSM method. For the analysis, panel data from 50 countries which participated in the 1979 Geneva Convention is used. The results demonstrate that the adoption of the Sofia Protocol had a significant effect on both environmental and economic performance while other three protocols had no discernible effect. In conclusion, it is important to consider each country's heterogeneity as well as their characteristic pollutants, not just the reduction of the pollutants when evaluating the effectiveness of the regimes.

3.1 Introduction

Since the United Nations Stockholm Conference on the Human Environment in 1972, global environmental degradation has been considered an important international policy issue (Kanie, 2007). In accordance with the current active discussion about the formation and implementation of global environmental governance, the number of international environmental regimes has rapidly increased. However, the persistent self-interestedness of international policy raises doubts about the effectiveness of IEAs. Consequently, scholars have devoted their efforts to evaluating the effectiveness of IEAs in terms of improving environmental quality. Since most IEAs contain diverse member countries and cover complex environmental problems, substantive analysis about the effect of IEAs before and after enforcement is only conducted from an academic point of view (Barrett, 2005), being considered insufficient for practical purposes. Moreover, exclusive institutions for post evaluation of the effectiveness of international environmental regimes are lacking to date.

Researchers who have conducted quantitative analyses about the effectiveness of IEAs have tried to foster better data sets and methodologies. However, because of the lack of sufficient research periods and difficulties in gaining data sets of diverse pollutants, various aspects of the effectiveness of IEAs are not extensively studied in many cases (Böhmelt & Pilster, 2010; Breitmeier et al., 2006; Mitchell, 2004). Therefore, most quantitative studies have focused on the environmental effectiveness of IEAs and concentrated on certain IEAs, which have relatively plentiful and accessible data sets, and a representative example is LRTAP (Aakvik & Tjøtta, 2011; Helm & Sprinz, 2000; Murdoch et al., 1997; Ringquist & Kostadinova, 2005; Vollenweider, 2013). However, only the environmental aspect was investigated, and the results from previous studies on the effectiveness of LRTAP remain in dispute, as the quantitative analysis on the effectiveness of IEAs is in the early stages.

This chapter attempts to answer the first and second research questions: *How do IEAs concerning different pollutants affect emission reduction in consideration of the emission reduction trends of participants and non-participants? How much economic burden is placed on member countries by participating in IEAs, and is there any possibility to simultaneously improve economic performance while reducing the pollutants of member* *countries?* For these purposes, this study evaluates environmental improvement and economic burden of IEAs with common responsibility in consideration of emission reductions and economic trends of participants and non-participants. The targets are the Helsinki Protocol (SO_X emissions) and the Sofia Protocol (NO_X emissions), which appear in many previous studies, and the Oslo Protocol (SO_X emissions) and the Geneva Protocol (NMVOC emissions) are also included in the analysis. Unlike previous studies, this chapter will re-examine and elaborate upon the effectiveness of LRTAP, with extensive research objects that include the economic effect on participants and advanced quantitative methodologies.

The chapter is organized as follows. Section 3.2 introduces brief information on LRTAP and representative quantitative studies on the effectiveness of LRTAP. Through this section, it is possible to grasp the research trend in LRTAP using quantitative methods and the shortcomings of existing studies. Section 3.3 explains the empirical models employed in this chapter. This chapter deals with the impact evaluation technique in depth, since applying the impact evaluation method to IEA analysis is one of the contributions of this thesis. Another reason is that the general methodologies of impact evaluation are also adopted in the other two main chapters; thus, it is important to understand these core methods. Section 3.4 presents data descriptions. Section 3.5 reports the result about the environmental and economic effectiveness of LRTAP. From this section, it is possible to widen the understanding of the effect of LRTAP on both environmental performance and economic growth. Finally, Section 3.6 concludes this chapter by identifying policy implications for establishing IEAs for sustainable development.

3.2 LRTAP: General Information and Quantitative Evidence

This section starts by introducing the LRTAP regime and proposing quantitative evidence of the effectiveness of IEAs focused on the protocols of LRTAP. The LRTAP regime is intended to protect the environment against air pollution and to reduce and prevent air pollution. The discussions about the convention on transboundary pollution begin with demonstrations of scientists about the interrelationship between sulfur emissions in continental Europe and the acidification of Scandinavian lakes. Moreover, studies that conclusively support the hypothesis that the influence area of air pollutants could reach several thousands of kilometers were presented from 1972 to 1977. Hence, the necessity of coping with transboundary pollution through cooperation at the international level has become apparent (United Nations Economic Commission for Europe (UNECE), n.d.).

After the Convention on Long-range Transboundary Air Pollution was addressed in 1979, it was signed by 34 governments and the European Community (EC). Figure 3.1 shows the distribution of member countries of this Convention. Fifty-one parties, including the EU, have participated in the Convention, and 32 parties are signatories to the Convention. The status of ratification of this convention is presented in Appendix 3.1.

Figure 3.1 **Member Countries of LRTAP**

Source: Wikipedia (n.d.).

In the text of the 1979 Convention, the definitions of key concepts and fundamental principles and other important rules for implementation of LRTAP are established (UNECE, n.d.). The Convention defines air pollution as "the introduction by man, directly or indirectly, of substances or energy into the air resulting in deleterious effects of such a nature as to endanger human health, harm living resources and ecosystems and material property and impair or interfere with amenities and other legitimate uses of the environment, and "air pollutants' shall be construed accordingly" (Article 1). Long-range transboundary air pollution is defined as "air pollution whose physical origin is situated wholly or in part within the area under the national jurisdiction of one state and which has adverse effects in the area under the jurisdiction of another state at such a distance that it is not generally possible to distinguish the contribution of individual emission sources or groups of sources" (Article 1).

Moreover, the principles of the Convention are specified as follows:

> The Contracting Parties, taking due account of the facts and problems involved, are determined to protect man and his environment against air pollution and shall endeavour to limit and, as far as possible, gradually reduce and prevent air pollution including long-range transboundary air pollution. (Article 2)

In addition, several capacity-building activities are conducted in the boundary of UNECE. For example, there is the active involvement of the countries of Eastern Europe, Caucasus, and Central Asia (EECCA) to enhance regional cohesiveness and the effectiveness of the Convention. They established the Working Group on Strategies and Review and agreed on an Action Plan to Involve Eastern Europe that discusses making action plans aiming at: 1) Raising political profile of the Convention in the region, 2) Encouraging ratification of the Convention's most recent protocols, 3) Increasing cooperation and exchange of information through expanding the modeling and monitoring activities, and 4) Supporting the EECCA countries involvement in the activities of the Convention (UNECE, n.d.). Recently, the workshop[12] was held in Tashkent, Uzbekistan, from November 20 to 21, 2013.

[12] "The workshop brought together national environmental, emission, public health experts and representatives of industrial sector of Uzbekistan to discuss the impact of particulate matter (PM) on health and the situation in Uzbekistan, as well as the current practice of emissions monitoring and reporting in the country. The international experts shared information on existing experience related to PM emission inventories development and on methods and tools used for that. The workshop participants developed recommendations on further steps to harmonize the national inventory system with the Convention's requirements" (UNECE, n.d.).

On the other hand, protocols that provide detailed information for reducing specific pollutants have been established since 1984 with the Protocol on Long-term Financing of the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP). Table 3.1 presents information about all protocols of LRTAP to date. Protocols have followed for setting specific emission reduction goals of air pollution. The protocols of LRTAP have been designed to cover various air pollutants, such as SO_X, NO_X, NMVOC, Persistent Organic Pollutants (POPs), and so on. More detailed information on each protocol is provided in Appendix 3.2.

Table 3.1 ***Protocols to LRTAP***

Year	Protocols	Parties	Date of entered into force
1999	Protocol to Abate Acidification, Eutrophication and Ground-level Ozone	25	17/05/2005
1998	Protocol on Persistent Organic Pollutants (POPs)	33	23/10/2003
1998	Protocol on Heavy Metals	33	29/12/2003
1994	Protocol on Further Reduction of Sulfur Emissions	28	05/08/1998
1991	Protocol concerning the Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes	24	29/09/1997
1988	Protocol concerning the Control of Nitrogen Oxides or their Transboundary Fluxes	35	14/02/1991
1985	Protocol on the Reduction of Sulfur Emissions or their Transboundary Fluxes by at least 30%	25	02/09/1987
1984	Protocol on Long-term Financing of the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP)	45	28/01/1988

Source: UNECE (n.d.).

Note: The shaded areas represent the research objects of this chapter.

UNECE demonstrates that LRTAP is generally regarded as a successful example of what can be achieved through intergovernmental cooperation. To discern objective evidence of the effectiveness of LRTAP on emission reductions, some previous studies have also tried to determine the relationship between participating in the protocol and environmental performance. Even though there has been a significant increase in the amount of research, there are few quantitative approaches, usually due to data unavailability. Moreover, it is true that quantitative analysis has been particularly limited in particular cases, especially in the Helsinki and Sofia Protocols.

Scholars who focus on the practical effectiveness of IEAs could measure the practical effect of LRTAP on emission reduction with the amount of changes of emissions using various measurement standards. More specifically, most quantitative studies that analyzed LRTAP emission changes of SO_X or NO_X were applied for measuring the practical effect of IEAs. The reason is that SO_X or NO_X data have been accumulated over long periods; thus, it is relatively easier to compile than other environmental performance data.

As a result, significant numbers of previous studies dealt with LRTAP protocols. Table 3.2 presents brief information on representative previous studies about LRTAP and it is shown that quantitative studies have concentrated on the protocols of SO_X or NO_X. Scholars have tried to determine the effectiveness of LRTAP using various methodologies and data; however, results are still controversial.

Table 3.2 ***Representative Quantitative Studies on the Effectiveness of LRTAP***

	Murdoch et al. (1997)	**Helm and Sprinz (2000)**	**Ringquist and Kostadinova (2005)**	**Aakvik and Tjøtta (2011)**	**Vollenweider (2013)**
LRTAP	Helsinki Sofia	Helsinki Sofia	Helsinki	Helsinki Oslo	Gothenburg
Nation	25 European countries	11 European countries	19 European countries	30 European countries	43 European Eurasian countries
Period	1980–1990	1980–1993 (SO_X) 1987–1994 (NO_X)	1980–1994	1960–2002	1995–2008
Pollutant	SO_X, NO_X	SO_X, NO_X	SO_X	SO_X	SO_2, NO_X
Result	Helsinki + Sofia ?	Helsinki + Sofia +	Helsinki ?	Helsinki ? Oslo ?	SO_2 ? NO_X ?

Note: In the results line, "+" indicates a positive effect of a protocol on emission reduction, and "?" indicates the effectiveness of a protocol is not identified in the statistical analysis.

The analysis of Levy (1993) on the Helsinki Protocol is the first quantitative approach on the effectiveness of LRTAP. He recognizes that LRTAP achieved success in consensus building and establishing rules for improving air quality while presenting a question about the independent effectiveness of the protocol. Through a comparison of 1990 forecast emissions based on 1981 emissions and 1989 actual emissions of SO_X, a significant SO_X emission reduction is observed in countries, since LRTAP affected emissions by creating knowledge of domestic damage and linkage politics. His analysis is relatively simple compared to follow-up studies; nevertheless, it marks a significant contribution to the field of IEA studies, since the result provides the first empirical evidence of the effectiveness of

LRTAP.

Moreover, Murdoch et al. (1997) survey 25 European nations to evaluate the effectiveness of the Helsinki and Sofia Protocols. The motivation of this study is that they impugn the different responses between the Helsinki Protocol and the Sofia Protocol on the emission levels of SO_X and NO_X. They demonstrate that while most countries have achieved or exceeded SO_X emission reductions of 30%, which is targeted in the Helsinki Protocol, the performance of NO_X emission reductions is not significant notwithstanding the Sofia Protocol. In this context, considering the concept of voluntary reduction, models are divided into before and after ratification. They find that the Helsinki Protocol reduces more SO_X emissions compared to expected reductions without protocol; however, the result of the Sofia Protocol is not robust in the model.

Helm and Sprinz (2000) also analyze the effectiveness of IEAs using the Helsinki Protocol and the Sofia Protocol considered separately. In their study, the effectiveness is defined as “the relative distance that the actual performance has moved from no-regime counterfactual toward the collective optimum or as the percentage of the regime potential that has been achieved” (Helm & Sprinz, 2000, p. 636). With this definition, they provide a systematic tool for evaluating the effectiveness of international environmental institutions (refer to Figure 2.5). They argue that the LRTAP regime is effective in reducing SO_X and NO_X emissions for the period of the 1980s to the early 1990s based on empirical results that show that the aggregated effectiveness score is 0.39 for the Helsinki Protocol and 0.31 for the Sofia Protocol, within the score range from 0 to 1. From this result, the Helsinki Protocol is slightly more effective in terms of emission reduction than the Sofia Protocol.

On the contrary, Ringquist and Kostadinova (2005) demonstrate that the effect of a protocol itself is ambiguous, even though nations ratifying the Helsinki Protocol have experienced significant emission reductions in the traditional model as well as in many previous studies. This is an unusual result because most previous quantitative studies have observed empirical evidence that IEAs have a positive effect on the reduction of pollution, and IEAs are regarded as effective. In their analysis, it is pointed out that ratification of the protocol is not random, but previous studies have not considered this. Moreover, they emphasize that “policy effectiveness must be estimated from self-selected samples” (p. 86) and insist that most previous studies have been biased in assessments of policy effectiveness, since they fail to control factors other than the Helsinki Protocol influence SO_X emissions. Therefore, Ringquist and Kostadinova (2005) investigate the effectiveness of IEAs by using the case of the 1985 Helsinki Protocol with various models including a random trend model and compare the results between traditional models and advanced models that control the non-random nature of ratification. For controlling the formidable obstacles of time series data, non-protocol factors and non-random processes, they analyze several models step-by-step to estimate consistent protocol effects.

Additionally, Aakvik and Tjøtta (2011) emphasize the accuracy of quantitative analysis, so they control for non-random processes utilizing DID estimation. This method is an advanced quantitative approach for controlling external factors (besides the effectiveness of IEAs). Moreover, this research explicitly redresses the lack of empirical analysis of the Oslo Protocol. They investigate the effect of IEAs with regard to the Helsinki and Oslo Protocols using panel data from 30 European countries from 1960 to 2002. They determine that no significant effect on reducing emissions is observed for either the Helsinki Protocol or the Oslo Protocol. Interestingly, in their previous analysis with randomly generated placebo protocols, Aakvik and Tjøtta (2007) posit that the Helsinki and Oslo Protocols are effective agents of reduction in SO_X emissions. They find that participating in a protocol has a positive effect on reducing SO_X emissions—participating in the Helsinki Protocol reduces SO_X emissions by 3% per year, and the Oslo Protocol, 4%.

In a recent study, Vollenweider (2013) investigates the influence of the Gothenburg 1999 Protocol on states' emission behavior. This study also adopts the DID model in consideration of the counterfactual situation. From the analysis of 43 European and Eurasian countries from 1995 to 2008, it is revealed that there are no significant effects of participating in LRTAP on a country's pollution emitting behavior in either NO_X or SO_2 emissions. In terms of the results, the author demonstrates that there are three possible explanations. First, the Gothenburg Protocol fails to encourage member countries to reduce NO_X and SO_2

emissions. Second, the effect of IEAs on non-member states by exploring spillover and network effects are also suggested. Finally, he states that since the analyses do not take into account a required timing for affecting states' behavior after regime participation, only limited findings are possible at present.

In summary, existing literature about the effectiveness of LRTAP on emission reduction shows contradictory experimental results. The diametrical quantitative analysis results show that the empirical evidence about the practical effectiveness of IEAs and the sensibility of the quantitative methodology are still controversial. Furthermore, almost all quantitative analyses on the effectiveness of LRTAP are focused on the change in environmental performance. In this respect, this chapter endeavors to determine environmental improvement and economic burden of LRTAP in consideration of emission reductions and economic trends, respectively, of participants and non-participants.

3.3 Empirical Models

Scholars have insisted that there are many external factors that can affect the effectiveness of IEAs, such as emission trends. Aakvik and Tjøtta (2011), who adopt the DID method to estimate the real effectiveness of the Helsinki and Oslo Protocols, assert that if an environmental awareness, a level of technology, and an ideology have a positive correlation, it is quite possible that estimated the effect of IEAs can be biased, triggering the problem of endogeneity:

> Many unobserved variables potentially affect both political propensity to sign a protocol and willingness to reduce sulphur emissions. For example, environmental awareness on the part of the constituency may affect both the propensity to sign an international environmental agreement to reduce sulphur emissions and the implementation of policies toward reducing domestic sulphur emissions. If there is a positive correlation between environmental awareness in the constituency and the signing of an international agreement, it will create an upwardly biased estimate of the effect when using standard regression models. We solve this problem of endogeneity by using a difference-in-difference approach. (p. 346)

Mitchell (2003) also insists that previous analyses conducted by environmental economists usually ignore "factors that explain variation in pollution across countries" (p. 449). He emphasize a need for considering factors with the comment that "economic, technological, political, and other drivers of behavior as explanatory variables in an analysis allows their use as control variables and demonstrates that covariation between an IEA and some outcome persists even after controlling for other factors" and "[t]his also allows assessment of whether an IEA's influence depends on, and is large or small relative to, these other influences" (p. 449). Moreover, it is difficult to consider counterfactuals in the quantitative analysis. As Zürn (1998) mentioned, "[t]he real measure of a given regime's effectiveness involves a comparison with what would have happened had the regime never existed” (p. 638).

However, to evaluate the effectiveness precisely from the issue-specific point of view, building counterfactuals is a very important task. In this regard, controlling for these factors and predicting hypothetical situations are regarded as tricky tasks in the field of quantitative analysis of the effectiveness of IEAs (Aakvik & Tjøtta, 2011; Frantzi, 2008; Ringquist & Kostadinova, 2005; Underdal, 1992; Vollenweider, 2013). This technical difficulty is one of the reasons for the conflicting result, despite attempts to redress this shortcoming with various quantitative methods.

Figure 3.2 and Figure 3.3 show why the counterfactual outcomes have to be considered when estimating the program effect. First, Figure 3.2 presents a with-and-without comparison.

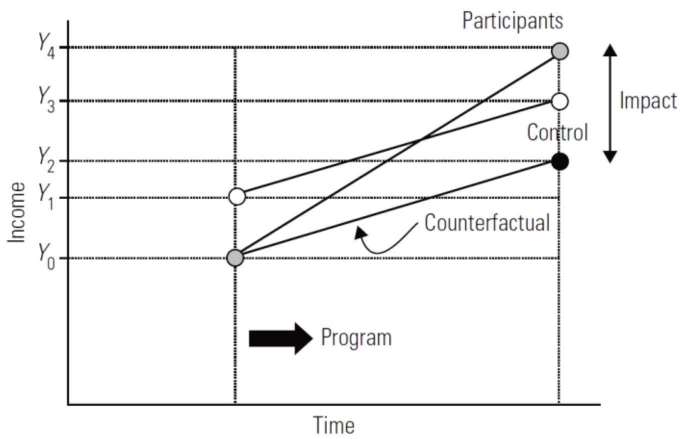

Figure 3.2 **Using a With-and-without Comparison**

Source: Khandker et al. (2010).

In this situation, the program's effect is measured by $(Y_4 - Y_3)$. However, if there are underlying differences in socioeconomic conditions, such as incomes, Y_3 could not be the right counterfactual outcome for estimating the program's effect. If one gets the information about the counterfactual outcomes (Y_0, Y_2), the real program effect can be measured by $(Y_4 - Y_2)$.

Next, in the before-and-after comparisons of Figure 3.3, the program's effect could be simply measured from $(Y_2 - Y_0)$. However, since this simple difference method does not consider other external factors outside of the program, there is a possibility that the participant's outcome in the absence of the program could be Y_1, instead of Y_0. Therefore, without controlling for those factors, the estimated program effect can be biased.

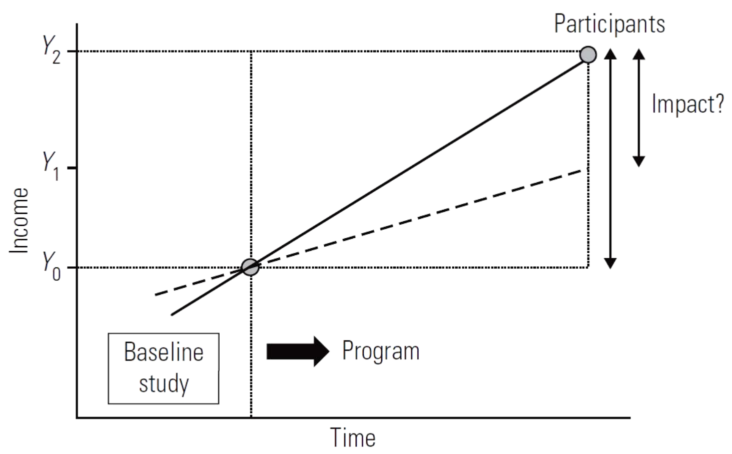

Figure 3.3 **Using a Before-and-after Comparison**

Source: Khandker et al. (2010).

From this discussion, it is possible to understand whether the analysis model does not consider the counterfactual situation, indicating that the program impact is inevitably biased. In other words, the program impact can be underestimated or overestimated if the counterfactual situation is not contemplated.

However, there is still the possibility of improvement with advanced impact evaluation methodologies. Throughout this thesis, the environmental and economic effectiveness of IEAs are evaluated by utilizing advanced impact evaluation methods—the PSM and DID methods—for a more precise analysis (Aakvik & Tjøtta, 2011; Khandker et al., 2010; Vollenweider, 2013). Chapters 3 and 4 evaluate the environmental and economic effectiveness of LRTAP and the Kyoto Protocol by using the impact evaluation method, which combines the PSM and DID methods based upon Khandker et al. (2010). Chapter 5 also adopts this method to generate the data set of the economic effectiveness of several IEAs. Therefore, to widen the understanding of the methodologies that form the basis of the whole thesis, this section examines the impact evaluation method combining the PSM and DID methods in detail.

3.3.1 PSM and DID Methods. The DID and PSM methods are already widely used in the fields of ODA, economics, and politics for evaluating program effectiveness (Cadot et al., 2012; Michalek, 2012; Mu & Van de Walle, 2007). However, there are not sufficient previous studies in the field of IEAs (Aakvik & Tjøtta, 2011; Vollenweider, 2013). These impact evaluation methods have their own advantages; it is possible to make a synergy effect by combining these two impact evaluation methodologies. Khandker et al. (2010) suggest the way to refine the DID method is “by using PSM with the baseline data to make certain the comparison group is similar to the treatment group and then applying double differences to the matched sample” (p.198).

Through the DID method combined with the PSM method, selection bias and the problem of unobserved heterogeneity can be controlled, as this method is based on selecting on observed characteristics. The process of matching propensity scores constructs a statistical comparison group from a model of the probability of participating in the program on the observed characteristics, and then, object variables of participants and non-participants with similar propensity scores are compared to evaluate the program effect. Moreover, it is possible to set counterfactuals quantitatively by means of the DID estimator. Khandker et al. (2010) demonstrate that comparing actual and counterfactual outcomes is a very crucial but tricky task, since the same sample with and without a program cannot be observed at the same time:

> The problem of evaluation is that while the program’s impact (independent of other factors) can truly be assessed only by comparing actual and counterfactual outcomes, the counterfactual is not observed. So the challenge of an impact assessment is to

create a convincing and reasonable comparison group for beneficiaries in light of this missing data. […] Finding an appropriate counterfactual constitutes the main challenge of an impact evaluation. (p. 22)

The DID method compares observed changes in the outcomes for a sample of participants and non-participants between the year of adoption and the target year. This method assumes that the unobserved heterogeneity in participation is time invariant, so the bias can be eliminated by the differencing process[13]. Therefore, "[c]alculating the average difference in outcomes separately for participants and nonparticipants over the periods and then taking an additional difference between the average changes in outcomes for these two groups will give the DD impact" (Khandker et al., 2010, p.74).

Pufahl and Weiss (2009) also point out the importance of measuring the real effect of the program with the case of evaluating the effects of farm programs in Germany. They demonstrate that this situation is the "classical evaluation problem" where the counterfactual situation is difficult to estimate in the program evaluation:

An individual farmer will participate only if the additional benefits exceed the costs of participation. Costs and benefits will differ between individuals depending on specific characteristics of the farm as well as the farm family, some of which, however, may not fully be observed (unobserved heterogeneity). The existence of

[13] This assumption means $(Y_3 - Y_2) = (Y_1 - Y_0)$ (Refer to Figure 3.2).

> systematic differences between program participants and non-participants requires separation of the "true" effect of program participation ("causal effect") from the effect of initial differences in characteristics of the two groups ("selection effect"). (pp. 80–81)

Therefore, by means of combining these two methodologies, it is possible to resolve the weak point of each (Khandker et al., 2010). In other words, there is the potential that improving the statistical model can be helpful to attain a more accurate result of the effectiveness of IEAs. First, to establish a statistical comparison group for the analysis, this study applies the PSM method. According to Khandker et al. (2010), two conditions should be satisfied to ensure the validity of the PSM method: 1) conditional independence (observed factors do not affect participation) and 2) sizable common support or overlap in propensity scores across the participant and non-participant sample. These two conditions are formally defined as two prerequisite assumptions for calculating the propensity score: the Assumption of Conditional Independence and the Assumption of Common Support, respectively.

For the Assumption of Conditional Independence, Khandker et al. (2010) state that observable covariates *X*, which are the observed characteristics of nations in this study, are not influenced by treatment. They note that:

> Conditional independence is a strong assumption and is not a directly testable criterion; it depends on specific features of the program itself. If unobserved

characteristics determine program participation, conditional independence will be violated, and PSM is not an appropriate method […]. Having a rich set of preprogram data will help support the conditional independence assumption by allowing one to control for as many observed characteristics as might be affecting program participation (assuming unobserved selection is limited). Alternatives when selection on unobserved characteristics exists, and thus conditional independence is violated, are discussed in the following chapters, including the instrumental variable and double-difference methods. (p. 56)

The next assumption is the Assumption of Common Support, which is related with Figure 3.3. This condition supposes that observable covariates of nations of the research objects, which are participants and non-participants of IEAs in this study, have comparison observations nearby in the propensity score distribution. More details about these two assumptions are provided with the following explanation of the analysis.

The first step of the application of the PSM method is estimating a model of program participation. In this study, participation in LRTAP is determined by whether a country participates. The basic model of the PSM estimator is as follows. Here, Y_i^T is the environmental or economic performance of the participating nation, and Y_i^C is the environmental or economic performance of the non-participating nation. T_i represents the participation in IEAs, and X_i represents the observable covariates of nations. In addition, Y_i^C

is also separated from treatment assignment T because of the Assumption of Conditional Independence:

$$\left(Y_i^T, Y_i^C\right) \perp T_i \mid X_i \tag{3.1}$$

For calculating the propensity score, the observed characteristics of nations X have to be assumed for defining the region of common support and balancing tests. In this analysis, GDP and population are used for the environmental effectiveness model for the observed characteristics. In this way, the empirical analysis by means of a relatively simple formulation has been used extensively in economic related fields, such as the environmental Kuznets curve. Furthermore, the adoption of the two-variable model of GDP and population appears reasonable, since it is able to secure a sufficient sample with the matching process of the PSM estimator. For the economic effectiveness model, the status of pollution is appended to GDP and population. It is noteworthy that these variables are regarded as the suitable variables for calculating the propensity score, since they represent socioeconomic conditions and the original status of the natural environment as well. In this step, every sample of the propensity score is estimated:

$$\hat{P}(X|T=1) = \hat{P}(X) \tag{3.2}$$

The next step of the PSM method is defining the region of common support and balancing tests. In this process, some of the non-participants may be dropped, since they are not included in the common support. In other words, those dropped observations are not representative of IEA participants. Figure 3.3 shows examples of desirable common support and weak common support of participants and non-participants. In the first example of Figure 3.4, the distributions of density of propensity scores for non-participants and participants overlapped well, while the second case fails to reach a substantial region of common support.

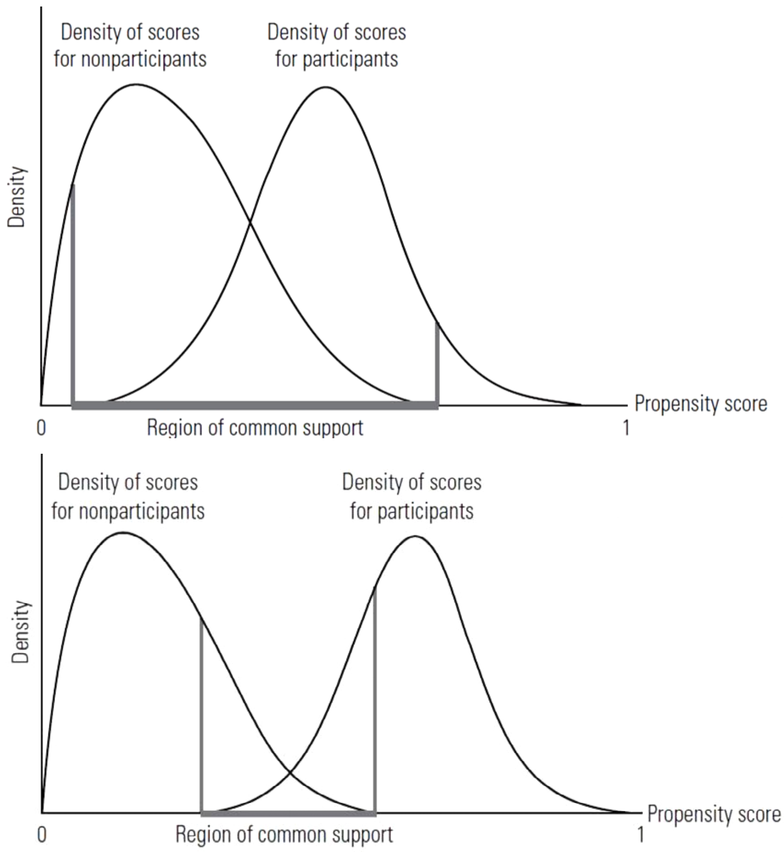

Figure 3.4 **Example of Desirable Common Support and Weak Common Support**

Source: Khandker et al. (2010).

The next process is the balancing test, which is conducted subsequently to identify whether the distributions of the treated group and comparison group are similar. They must be balanced in the propensity scores, which are calculated by the observed characteristics of nations X:

$$\hat{P}(X|T = 1) = \hat{P}(X|T = 0) \tag{3.3}$$

The final step of the PSM method is matching participants to non-participants. There are various matching criteria to allocate participants to non-participants (e.g., nearest-neighbor matching, caliper or radius matching, stratification or interval matching, kernel and local linear matching, and DID matching). First, nearest-neighbor matching is the most commonly used matching criterion that matches samples with the closest propensity score. Second, caliper or radius matching is designed to compensate for the problem of nearest-neighbor matching (high difference in propensity scores between a participant and the non-participant that is judged as the closest neighbor). This criterion imposes a threshold on the maximum propensity score distance, which is called the caliper, to match within a certain range of propensity scores. As a result, the dropping of many samples remains a weakness. Third, stratification or interval matching divides the common support into several intervals, and the program effect is estimated as the mean difference between participants and non-participants within each interval. Next, kernel and local linear matching are based on nonparametric matching estimators. More specific information on each method can be found in Khandker et al. (2010).

In the present study, DID matching, which combines traditional PSM and DID methods, was applied for the matching criteria. Khandker et al. (2010) demonstrate that if there are participant and control observations before and after program data, the DID matching estimator can be conducted to better match control and treated observations on a pre-program feature, X (Khandker et al., 2010). This matching criterion was adopted to take advantage of the obtained panel data. A more specific explanation is provided by Khandker et al. (2010) as follows:

> [I]mportantly, it allows for unobserved characteristics affecting program take-up, assuming that these unobserved traits do not vary over time. To present the DD estimator, revisit the setup for the crosssection PSM estimator […] With panel data over two time periods *t* = {1, 2}, the local linear DD estimator for the mean difference in outcomes *Yit* across participants *i* and non-participants *j* in the common support is given by: $TOT^{DD}_{PSM} = \frac{1}{N_T}\left[\sum_{i\in T}(Y^T_{i2} - Y^T_{i1}) - \sum_{\in C}\omega(i,j)\left(Y^C_2 - Y^C_1\right)\right]$
>
> (p. 61)

Since the country-based panel data across the two periods and across the matched regime participants and non-regime countries is prepared, DID matching criteria can be adopted. “This method assumes using a standard linear model for outcomes and for estimating the TOT and applying weights on the basis of the propensity score to the matched comparison group” (Khandker et al., 2010, p.61). Therefore, it is possible to control the sample selection problem on unobserved characteristics by assuming these characteristics are time-invariant. Van de Walle and Cratty (2002), who assess the welfare impacts of rural roads using impact evaluation combining the DID method with the PSM method, emphasize the advantages of using panel data in program effectiveness evaluation:

> An advantage of having panel data is that it allows us to control for idiosyncratic unobservable that may influence selection into the program. (This is the standard sample selection problem on unobservable in the econometrics parlance). This is not feasible with cross-section data. Assuming that these unobservable can be represented as a time-invariant error component, selection bias can be eliminated by taking first differences over time. Propensity score matching using panel data also allows us to separate the impact of the roads from the general economic development which would have happened had there been no roads project. (p. 20)

Upon this matching criteria based on the propensity score, only selected matched countries are used for the DID analysis for both the adoption year and the target year. In this chapter, the PSM process is conducted in the databases of four protocols. The DID matching approach assumes that unobserved characteristics affecting a program at the beginning do not change over time. This approach uses two-time-periods, $t = \{1, 2\}$, the adoption year and the target year of each protocol of LRTAP, respectively. As a result, the DID estimator for the mean difference is the effectiveness of each protocol of LRTAP, and Y_{it} of participants *i* and other non-participants *j* with the weight $\omega(i, j)$ calculated by the PSM estimator are measured by this equation. In this equation, Y_i^T indicates environmental performance or economic performance of participating countries, and Y_i^C indicates other non-participating countries' performance:

$$DD_i = (Y_{i2}^T - Y_{i1}^T) - \sum{}_{\in C} \omega(i,j)\left(Y_{i2}^C - Y_{i1}^C\right) \tag{3.4}$$

The DID matching approach can be estimated with a regression framework as follows (Khandker et al., 2010). The program effect can be captured by β, the coefficient of the program participating variable. The dependent variable ΔY_{it} is the environmental or economic performance of the country i at year t. The independent variable T_i indicates whether the country participates in IEAs or not, and other control variables, such as the time dummy, are included in the variable X_{it}:

$$\Delta Y_{it} = \alpha + \beta T_i + \gamma \Delta X_{it} + \varepsilon_{it},\ \beta =\ the\ program\ effect \tag{3.5}$$

$\emptyset$).

Furthermore, for a more precise analysis, the panel fixed-effect model is used based on the result of the Wu–Hausman test, which identifies an appropriate model between the fixed-effect model and the random-effect model. If the test result rejects the null hypothesis, this indicates that there are no systemic differences. Therefore, it is possible to ascertain whether the fixed-effect model is consistent in the model or not. Borenstein et al. (2009) offer the differences between the fixed-effect model and the random-effect as follows:

> Under the fixed-effect model we assume that there is one true effect size (hence the term fixed effect) which underlies all the studies in the analysis, and that all differences in observed effects are due to sampling error. While we follow the practice of calling this a fixed-effect model, a more descriptive term would be a common-effect model. In either case, we use the singular (effect) since there is only one true effect. By contrast, under the random-effects model we allow that the true effect could vary from study to study. (p.61)

Consequently, from this DID matching approach with the fixed-effect model based on the result of the Wu–Hausman test, it is possible to control time-varying covariates and unobserved time-invariant individual heterogeneity. By differencing both the right- and left-hand sides of the equation, the treatment effect is calculated from the coefficient of ΔT_{it} (i.e., $\emptyset$).

$$(Y_{it} - Y_{it-1}) = \emptyset(T_{it} - T_{it-1}) + \delta(X_{it} - X_{it-1}) + (\eta_i - \eta_i) + (\varepsilon_{it} - \varepsilon_{it-1})$$

$$\Rightarrow \Delta Y_{it} = \emptyset \Delta T_{it} + \delta \Delta X_{it} + \Delta \varepsilon_{it} \quad (3.6)$$

To examine two dimensions of the effectiveness, the two different models are analyzed for testing the environmental effectiveness and the economic effectiveness, respectively. The most important part of both of these two models is the program effect variables, which are contained as the IEA dummy. These variables are defined by being affiliated to each protocol of LRTAP, and receive a value of 1 if the country i has joined in the protocol in year t and 0 otherwise.

As Mitchell (2002) demonstrates, control variables that can affect the effectiveness of IEAs must be included for a more precise estimation. The model proposed in this chapter is expected to estimate the effectiveness precisely while containing a relatively small number of control variables, since the PSM process already considers the observed characteristics of nations and the DID method with the fixed-effect model controls time-varying covariates and unobserved time-invariant individual heterogeneity.

The environmental effectiveness model includes the GDP and population variables that are used in the calculation of the propensity score. Note that, based on Mitchell (2002), the dummy variables, which indicate the effect of regime membership, are included in the equation. The IEA and time dummy are appended to estimate the environmental effectiveness of the protocols of LRTAP. Formally, the following environmental effectiveness model is used for the test:

$$ln(\text{Emissions}) = \alpha_0 + \alpha_1\text{IEA dummy} + \alpha_2\text{GDP} + \alpha_3\text{POP} + \alpha_4\text{Time dummy} \quad (3.7)$$

The economic effectiveness model was derived from the Cobb–Douglas GDP function. This function is a type of production function that represents the contributions of inputs to economic growth. Hence, components of GDP function—such as capital, labor, and human capital—were included in the economic effectiveness model, whereas the model above had the variables related with GDP. The program effect variable, the IEA dummy, and the time dummy variable were contained similarly to the environmental effectiveness model. The economic effectiveness model is described as follows. All statistical analysis of the impact evaluation technique combining the PSM and DID methods is conducted by STATA/SE 11.2 for Windows (32-bit).

$$\begin{aligned}\text{GDP} = \beta_0 + \beta_1\text{IEA dummy} + \beta_2\text{Capital} + \beta_3\text{Labor} + \beta_4\text{Human capital} \\ +\beta_5\text{Time dummy} \quad (3.8)\end{aligned}$$

3.3.2 Two-time-period Setting. Previous quantitative studies about the effectiveness of IEAs are limited in covering analysis periods in which the effect of IEAs is revealed and comparing participating nations and other nations. Appendix 3.3 shows these gaps between previous studies and member countries of each protocol. Through this advanced approach with the DID and PSM methods, it is feasible to take account of not only a with-and-without comparison but also a before-and-after comparison. Accordingly, a two-time-period setting, consisting of a base year and a target year, is needed. For the DID analysis, it is crucial to set those two-time-periods carefully for a robust result because a two-time-period setting can affect outcomes of the whole program impact analysis.

The base year had to be set as the time that IEA was introduced, so an adoption year, an effectuation year, or a ratification year can be used. Aakvik and Tjøtta (2011), who measure the effectiveness of the Helsinki and Oslo Protocols using the DID estimation method, consider that the year following the adoption year is the initial point of potential effect. Therefore, based on previous studies and data availability of the research periods, the analysis uses the adoption year of each protocol as the base year for the DID method.

The target year (the year that is used to determine the effectiveness of the program) has to be decided. For setting the target year of IEAs, it is useful to examine the context of the agreement. There are IEAs that specify a goal year for reductions in emissions of pollutants, and participants try to improve their environmental performance during this period. Thus, this target year of each IEA can be used as the objective target year of IEAs. Helm and Sprinz (2000) and Aakvik and Tjøtta (2011) also regard the goal year of LRTAP as the target year that can estimate the IEA effect. In this study, the goal years of LRTAP protocols, are used as the target years. The logical bases of the target years from the Articles of each protocol are presented in Appendix 3.4.

3.4 Data Description

The goal of this study is to evaluate the environmental and economic effectiveness of LRTAP with a country-based panel data set from 1970 to 2005 including 50 parties (not including the EU as a whole) of the 1979 Geneva Convention on Long-range Transboundary Air Pollution, which is the parent body of LRTAP protocols (refer to Appendix 3.1). The country-based panel data of each protocol are established through the process of examining pollution data availability and the possibility of adopting the matching criteria. As mentioned in Appendix 3.3 and Section 3.3.1, most previous studies fail to satisfy research objects and periods for robust empirical analyses. In this respect, this study tries to secure the database with the wide range of country-based panel data of member countries of the 1979 Geneva Convention.

In this chapter, four protocols (the Helsinki, Sofia, Oslo, and Geneva Protocols) are extracted for the empirical analysis about the effectiveness of LRTAP. Even though eight protocols have been adopted since the Geneva Convention of 1979, only four protocols satisfy data availability requirements for the analysis. Moreover, the context of each protocol is also taken into account for determining whether the protocol reduces substantial effort from participants. In particular, the Geneva Protocol, which aims at the prevention of NMVOC emissions, is also included to expand the research objects. Another significance of this study is that the economic effect on the member countries is investigated simultaneously for the first time in the quantitative analysis of IEAs for establishing the effectiveness of IEAs in terms of sustainable development. Specific information on the status of the participant countries of each protocol is presented in Appendixes 3.5, 3.6, 3.7, and 3.8.

The sources of data used in the analysis are presented in Table 3.3. Throughout those four protocols, data on the adoption status, which is considered a critical variable in both the environmental and the economic models, is collected from the homepage of the LRTAP secretariat (UNECE, n.d.), IEA Database Project by Mitchell (Mitchell, 2013), and UNEP (2005). This variable is one of the binary indicators that gains 1 if a nation is a member of the protocol and 0 otherwise. Moreover, each model has two more binary indicators: the time dummy and the group dummy.

In the DID analysis, the interaction variable of the time and group dummy indicates the effectiveness of IEAs. The time dummy is divided into the base year and the target year. This variable is given the value 1 if the data is about the target year and 0 if the data is about the adoption year. It is noteworthy that the result of the group dummy that reflects the control group is omitted because of collinearity in the analysis of this chapter.

Table 3.3 ***Sources of Data***

Variables	Sources
Status of participating in IEAs	LRTAP officially reported emission data (UNECE, n.d.), IEA Database Project (Mitchell, 2013), UNEP (2005)
Social factors (GDP, Population)	WDI (World Bank, n.d.)
Environmental performance	LRTAP officially reported emission data (UNECE, n.d.), Stern's SO_2 emissions data (David Stern's Data site, n.d.)
Capital	WDI (World Bank, n.d.)
Labor	WDI (World Bank, n.d.), ILO Data set (ILO, n.d.)
Human capital	Barro and Lee (2011)

Source: Author.

For the environmental model, the environmental performance data of each protocol is adopted for the object variable. Therefore, SO_X, NO_X, and NMVOC data from Centre on Emission Inventories and Projections (CEIP), which is the officially reported emission data by LRTAP, are used for the analysis. More specifically, the emission data on SO_X emissions[14] for the Helsinki and Oslo Protocols, NO_X emissions[15] for the Sofia Protocol, and NMVOC emissions[16] for the Geneva Protocol are required for the quantitative analysis. However, the

[14] "Sulphur oxides (SO_X) means all sulphur compounds, expressed as sulphur dioxide (SO_2). The major part of anthropogenic emissions of sulphur oxides to the atmosphere is in the form of SO_2 and, therefore, emissions of SO_2 and sulphur trioxide (SO_3) should be reported as SO_2 in mass units. Emissions of other sulphur compounds such as sulphate, sulphuric acid (H_2SO_4) and non-oxygenated compounds of sulphur, e.g. hydrogen sulphide (H_2S), are less important than the emissions of sulphur oxides on a regional scale. However, they are significant for some countries. Therefore, Parties are also recommended to report emissions of all sulphur compounds as SO_2 in mass units" (UNECE, 2009).

[15] "Nitrogen oxides (NO_X) means nitric oxide and nitrogen dioxide, expressed as nitrogen dioxide (NO_2)" (UNECE, 2009).

[16] "NMVOCs means any organic compound, excluding methane, having a vapour pressure of 0.01 kPa or more at 293.15 K, or having a corresponding volatility under the particular conditions of use. For the purpose of these

pollutant data from the LRTAP secretariat is collected from 1990 to 2005; thus, it is impossible to cover the whole research period of the Helsinki Protocol adopted in 1985. Hence, SO_X data from the David Stern data page, which was established in 1850, is used for the Helsinki Protocol. GDP and population, which are the socioeconomic control variables, are from WDI by World Bank (n.d.).

Next, for the economic model, more variables representing the GDP function model are needed. The capital data is from gross fixed capital formation (constant 2000 US dollars) and the labor data is from the total labor force participation rate (% of total population ages from 15 to 64) of WDI. However, as the labor force participation rate of WDI covers from 1990 only, the Labor Statistics Database from LABORSTA of the International Labor Organization (ILO) is used for the analysis of the Helsinki Protocol. Next, the human capital data is from Barro and Lee (2011), which is a famous database of human capital. They provide educational attainment data for 146 countries in five-year intervals from 1950 to 2010 and information about the distribution of educational attainment of the adult population over age 15 and over age 25 by sex at seven levels of schooling (Barro & Lee, n.d.). However, this database is collected at an interval of five years, and data from the nearest year to the adoption year and the target year is adopted for the empirical analysis. Table 3.4 offers the specific information about the time setting of human capital data.

Guidelines, the fraction of creosote which exceeds this value of vapour pressure at 293.15 K should be considered as NMVOCs" (UNECE, 2009).

Table 3.4 ***Setting Years of Human Capital Data***

LRTAP	Helsinki	Oslo	Sofia	Geneva
Pollutants	SO_X		NO_X	NMVOC
Adoption year	1985	1994	1990	1991
Year of data	1985	1995	1990	1990
Target year	1993	2004	1995	1999
Year of data	1995	2005	1995	2000

Source: Year of data is from Barro and Lee (2011).

With the various data introduced above, the panel data of each protocol were produced based on the process of the impact evaluation method. Via the matching process, each panel data consisted of two-time-periods—the adoption year and the target year—for participants and non-participants of protocols. The final analysis with the fixed-effect model is conducted four times, since the data are separated by protocols. The descriptive statistics of the full data before matching are shown in Table 3.5.

Note that the dummy variables, such as the regime effectiveness variable, are not included in this table, since they are generated in the process of the PSM method. The descriptive statistics about the environmental effectiveness model and the economic effectiveness model of each protocol after matching are presented in Appendix 3.9 and Appendix 3.10, and it is possible to gain information about the dummy variables.

Table 3.5 ***Descriptive Statistics (Full Data before Matching)***

Variables	N	Mean	SD	Min	Max
SO_X (LRTAP)	638	952.148	2,705.796	0.040	20,935.500
SOx (Stern)	1,227	807.614	1,855.222	0.013	14,421.310
NO_X	642	1,092.561	3,230.059	0.309	21,697.700
NMVOC	1,018	1,103.549	3,301.641	0.000	23,892.000
Capital	1,312	830.952	2,337.497	1.000	22,000.000
Labor	878	11,792.280	23,792.400	137.762	160,000.000
Human capital	462	9.232	1.577	3.970	13.190
Population	1,870	22,346.240	42,907.000	31.232	300,000.000
GDP	1,460	4,019.517	12,456.110	6.000	120,000.000

Source: Author.

3.5 Results

3.5.1 Environmental Effectiveness. The environmental effectiveness results are presented in Table 3.6. There are two categories in the table, and the core variable is the regime participation variable, which is estimated by the dummy variable that takes 1 for participating in each protocol in this model. Therefore, the positive coefficient means a beneficial influence of IEAs on environmental performance of member countries, whereas the negative sign indicates an adverse effect. About 65 countries are used for the environmental effectiveness model.

Table 3.6 ***Environmental Effectiveness***

LRTAP		Helsinki	Oslo	Sofia	Geneva
Pollutants		SO_X		NO_X	NMVOC
Adoption year		1985	1994	1990	1991
Target year		1993	2004	1995	1999
Political variable	Regime participation	-199.264 (173.983)	-84.032 (169.586)	-590.246** (276.070)	-3.485 (75.638)
Other variables	Time dummy	-43.907 (128.277)	-102.114 (151.641)	159.085 (226.985)	-3.483 (49.256)
	Population	0.042 (0.056)	0.305** (0.114)	-0.352*** (0.114)	-0.019 (0.081)
	GDP	-0.108 (0.080)	-0.478*** (0.109)	0.818*** (0.253)	-0.314*** (0.089)
	Constant	185.330 (1197.688)	-3837.836* (2225.651)	8733.108*** (2459.044)	1601.815 (1088.779)
	R^2	0.392	0.788	0.439	0.774
	N	67	64	66	67
	Participating nations	20	21	38	17
	Non-participating nations	47	43	28	50

*Note1: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.*

Note2: The Sofia Protocol was adopted in 1988. However, the 1990 pollutant data was used as the Sofia Protocol of the adoption year due to data limitations.

First, the negative coefficients of the regime participation variables are observed in all four protocols, and these results indicate that participants of each protocol have fewer pollutants than non-participants. However, only the result of the Sofia Protocol shows statistical significance at the 5% level, while the results of other pollutants have no statistically significant effect between participation in protocols and emission reductions.

In this analysis model, the Helsinki and Oslo Protocols, which target SO_X emissions, are examined, and it is expected that the Oslo Protocol may be more effective than the Helsinki Protocol, since it imposed more advanced installations. Ringquist and Kostadinova (2005), who analyze the effectiveness of the Helsinki Protocol, also posit that "[t]he Oslo Protocol re-places the across-the-board goal of a 30% reduction in sulfur emissions with a set of country-specific emission reduction targets based upon "critical loads" for sulfur de-position in each signatory nation. Thus, the Oslo Protocol may be more effective" (p. 100). However, neither IEAs are effective on SO_X reductions according to the empirical findings of this chapter. Moreover, the analysis of the Geneva Protocol, which is the first quantitative investigation of NMVOC pollution, also reveals no significant differences between member countries and non-participants.

The robust result of the Sofia Protocol is in line with the previous study, which claims a significant effect on NO_X emission reduction (Helm & Sprinz, 2000). This controversial empirical result concerning various pollutants makes it clear that there exist possibilities that the effectiveness of IEAs on reducing emissions can be influenced by the characteristic of targeted pollutants. To find theoretical and empirical evidence about the effectiveness of IEAs, previous studies about the effectiveness of LRTAP are investigated. As a result, the reasons why the environmental effectiveness of other protocols except the Sofia Protocol is not robust could be interpreted based on the literature review.

Murdoch et al. (1997) clarify that nations that are already substantially reducing emissions are more likely to actively participate in LRTAP protocols. Furthermore, there would be efforts of non-participating nations to voluntarily reduce environmental pollution, owing to the elevated awareness of pollution problems in the society after the adaptation or ratification of a certain IEA. Therefore, even in the absence of the protocol, nations can be receiving impetus from sharing technologies related with preventing environmental pollution and scientific information between nations (Aakvik & Tjøtta, 2011; Ringquist & Kostadinova, 2005). LRTAP is intended for European countries to improve transboundary air pollution through enhancing cooperation and performing mutual interchange among nations more effectively than IEAs that cover the global spectrum (Aakvik & Tjøtta, 2011; Ringquist & Kostadinova, 2005). The protocol reflects a consensus on the need for reducing SO_X emissions that has emerged with industrial development. Therefore, technologies for desulfurization, such as flue-gas desulfurization (FGD), have come into wide use since the 1970s in developed countries, especially in the United States and Japan.

Moreover, since most IEAs are soft institutions that are socially important but non-legally binding instruments, voluntary and flexible obligations degrade the executive force of each party's environmental policies. For example, Barrett (2005) argues that there are difficulties of cooperation caused by self-enforcement among international regimes. If that is the case, it is difficult to catch the differences in the effectiveness of IEAs between participants and non-participants of the protocol.

In addition, from the point of view of the limitation in terms of IEA enforcement, Ringquist and Kostadinova (2005) indicate that more free riders of SO_X and NMVOC emissions than NO_X emissions may exist due to spillover. For instance, as mentioned before, it is true that desulfurization facilities have diffused from the 1970s, as countries require relatively low levels of technology and knowhow compared to those necessary for denitrification facilities. On the contrary, chemical denitrification technologies related to NO_X Storage and Reduction (NSR) are still in development. Therefore, it can be supposed that there are technology spillovers by advanced countries before establishing the protocol, and this is one of the reasons that not only participants but also non-participants of the Helsinki Protocol could attain SO_X emission reduction, as there were technology spillovers by advanced countries before establishing the protocol. The empirical result also indicates that there are more than 30% emission reductions regardless of participation in LRTAP.

Contrary to the results of other protocols, the coefficient of the Sofia Protocol is statistically robust and has a positive effect on NO_X emission reduction. This result is consistent with the positive arguments of Helm and Sprinz (2000) on the environmental effectiveness of the Sofia Protocol. This empirical evidence supports the assumption that there would be fewer active reducing behaviors among less capable countries because of the high cost and the need for advanced technologies for denitrification. Consequently, big gaps in de-nitrification abilities could emerge between participants and non-participants, and active efforts to reduce emissions could be limited in nations lacking capacity and resources. As a result, only member countries of the Sofia Protocol achieved significant NO_X emission reduction by taking the initiative of the protocol.

Of course, parts of previous quantitative studies about the effectiveness of the Sofia Protocol observed that there were no statistically significant contributions from participating in the protocol on NO_X emission reduction (Murdoch et al., 1997). However, limitations of data sets and methodologies of previous studies have been pointed out by various authors (Helm & Sprinz, 2000; Murdoch et al., 1997). For example, the Sofia Protocol was established with the aim to reduce national annual emissions of NO_X at the latest by 31 December 1994, as below (UNECE, n.d.):

> The Parties shall, as soon as possible and as a first step, take effective measures to control and/or reduce their national annual emissions of nitrogen oxides or their transboundary fluxes so that these, at the latest by 31 December 1994, do not exceed their national annual emissions of nitrogen oxides or transboundary fluxes of such emissions for the calendar year 1987 or any previous year to be specified upon signature of, or accession to, the Protocol, provided that in addition, with respect to any Party specifying such a previous year, its national average annual transboundary fluxes or national average annual emissions of nitrogen oxides for the period from 1

January 1987 to 1 January 1996 do not exceed its transboundary fluxes or national emissions for the calendar year 1987. (Article 2)

Therefore, analyzing the effectiveness of the Sofia Protocol with a database from after 1994 is desirable. However, Murdoch et al. (1997), who claim that the effect of the Sofia Protocol on NO_X reduction is ambiguous, use data prior to 1990; thus, it is difficult to be satisfied that the results have validity. As mentioned above, Appendix 3.2 shows the status of participants of LRTAP and research objects of previous studies. Moreover, even though one of the representative analyses about the effectiveness of the Sofia Protocol, Helm and Sprinz (2000), reveal that there are positive effects of the protocol in terms of cutting down NO_X emissions, the result may be biased because their analysis models did not consider the unobserved heterogeneity of research objects.

In the present study, through the impact evaluating method combining the PSM and DID methods with a sufficient data set, it is possible to overcome these kinds of technical obstacles. Using the PSM method, samples of counterfactuals could be matched with participants of the protocol, and by the DID process with the fixed-effect model, the unobserved heterogeneity of nations could be controlled. Thus, it is perceived that the effectiveness of LRTAP is investigated more accurately than in previous studies.

In the results of the control variables, the Sofia Protocol is distinguished from other protocols. The positive signs of the coefficients of the time dummy and GDP are shown only in the Sofia Protocol. However, the time dummy variables of all protocols, which reveal whether there are any differences before and after participating in the protocol, are not statistically robust. Therefore, it is clear that there is no robust reduction effect of LRTAP protocols before and after adaptation. For the results of the GDP variables that indicate the degree of nations' economic development, there are the negative coefficients in the three protocols except the Sofia Protocol. The coefficients of the protocols, except for the Helsinki Protocol, are statistically significant at the 1% level. Only the result of the Sofia Protocol demonstrates the positive sign of the coefficient, which indicates that there is improvement of economic performance with increasing NO_X emissions, while the signs of the coefficients of SO_X and NMVOC emissions show the opposite results.

As the above results indicate, NO_X is likely to have different characteristics from those of the other contaminants. In fact, Matsuoka et al. (1998) point out that, while some contaminants, such as SO_X, support the environmental Kuznets curve, NO_X does not fit in the inverted-U shape between GDP and emissions. Additionally, in some types of environmental degradation, such as in forest areas, social factors (population growth) have a stronger impact than economic factors. Thus, in comparing and examining the effectiveness of IEAs, it is important to simultaneously consider inherent differences from the context of each IEA and other external differences, such as the differences and features of the pollutants to be regulated, and the level and cost of environmental technology related to the IEA.

Additionally, the analysis in which the base year is set as the year entered into force[17] is conducted for checking the robustness of the DID analysis. As mentioned in Section 3.3.2, setting the base year and the target year in the DID method is a crucial process, since this can affect outcomes of the impact analysis heavily. In this chapter, the adoption year[18] of each protocol is regarded as the base year. However, owing to the big time lag in instituting legal proceedings among member countries, timing differences arise as a necessity. Therefore, the model based on the entry into force year is also considered in this chapter.

The results of the entry into force model in Table 3.7 are firmly consistent with the analysis of the adoption year in Table 3.6. The effectiveness of the LRTAP protocol is statistically significant at the 5% level only in the Sofia Protocol model. Furthermore, the direction of the coefficients is almost consistent with the empirical results of the adoption year model. As a result, it is found that the empirical results of this chapter about the

[17] The meaning of the entry into force is defined as "1. A treaty enters into force in such manner and upon such date as it may provide or as the negotiating states may agree. 2. Failing any such provision or agreement, a treaty enters into force as soon as consent to be bound by the treaty has been established for all the negotiating States. 3. When the consent of a State to be bound by a treaty is established on a date after the treaty has come into force, the treaty enters into force for that State on that date, unless the treaty otherwise provides. 4. The provisions of a treaty regulating the authentication of its text, the establishment of the consent of States to be bound by the treaty, the manner or date of its entry into force, reservations, the functions of the depositary and other matters arising necessarily before the entry into force of the treaty apply from the time of the adoption of its text" (Article 24) (United Nations (UN), 1980).

[18] The adoption means "[t]he adoption of the text of a treaty takes place by the consent of all the States participating in its drawing up except …The adoption of the text of a treaty at an international conference takes place by the vote of two-thirds of the States present and voting, unless by the same majority they shall decide to apply a different rule" (Article 9) (UN, 1980).

effectiveness of LRTAP, which set the base year as the adoption year, are statistically stable.

Table 3.7 ***Environmental Effectiveness of the Entry into Force Model***

LRTAP		Helsinki	Sofia	Geneva
Pollutants		SO_X	NO_X	NMVOC
Adoption year		1987	1991	1997
Target year		1993	1995	1999
Political variable	Regime participation	-244.385	-568.231**	-19.439
		(163.001)	(238.749)	(18.201)
Other variables	Time dummy	-36.082	213.189	-5.134
		(122.307)	(201.236)	(13.508)
	Population	0.010	-0.421***	-0.036
		(0.068)	(0.125)	(0.028)
	GDP	-0.041	0.887***	-0.112**
		(0.129)	(0.250)	(0.041)
	Constant	760.947	10762.59***	2342.971***
		(1348.682)	(2832.462)	(451.272)
	N	68	64	70

*Note1: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.*
Note2: The result of the Oslo Protocol is omitted due to failure in the matching process.

3.5.2 Economic Effectiveness. The next analysis focuses on the economic effectiveness of LRTAP. Table 3.8 refers to the economic effectiveness of each protocol of LRTAP with the GDP function variables. R^2 is over 85% in all the models, indicating that the high variation of cases can be explained by this model.

Table 3.8 ***Economic Effectiveness***

LRTAP		Helsinki	Oslo	Sofia	Geneva
Pollutants		SO_X		NO_X	NMVOC
Adoption year		1985	1994	1990	1991
Target year		1993	2004	1995	1999
Political variable	Regime participation	154.472	-9.183	434.092**	59.981
		(246.849)	(97.061)	(187.338)	(95.157)
GDP function variables	Time dummy	225.837	-319.195	53.950	-35.294
		(327.757)	(281.885)	(103.057)	(100.372)
	Capital	6.760***	4.153***	1.315	4.033***
		(1.313)	(0.470)	(1.173)	(0.204)
	Labor	279.739*	-0.168	0.370*	-0.093
		(158.778)	(0.203)	(0.189)	(0.111)
	Human capital	-516.825	347.154	-3.016	94.702
		(332.422)	(320.034)	(194.603)	(83.191)
	Constant	-247.946	81.956	-1862.771	376.359
		(3465.348)	(3608.645)	(1837.446)	(1200.963)
	R^2	0.972	0.966	0.851	0.935
	N	46	59	66	61
	Participating nations	18	21	36	17
	Non-participating nations	28	38	30	44

*Note 1: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.*

Note 2: The Sofia Protocol was adopted in 1988. However, the 1990 pollutant data was used as the Sofia Protocol of the adoption year due to data limitations.

Note 3: The Human capital data (Barro & Lee, 2011) is collected at five-year intervals.

First, the result from the key elements of economic effectiveness is presented in the regime participation variable. Similar to the previous result of environmental effectiveness, only the variable of the Sofia Protocol is statistically significant at the 5% level. This result indicates that there exists statistically significant improvement of GDP among member countries due to participating in the Sofia Protocol. Since the previous result about environmental effectiveness demonstrates a positive coefficient of the GDP variable in the Sofia Protocol, it can be conceived that these two results about the Sofia Protocol coincide.

In the case of the variables about elements of the production function, it is possible to determine the relationship between each production function variable and various air pollution substances. The capital variable is positively significant at the 1% level in the Helsinki, Oslo, and Geneva models but not significant in the Sofia model. Increasing capital can have positive effects on reducing SO_X and NMVOC emissions, while there is no significant effect on NO_X emissions. These empirical results also show the characteristics of NO_X that differ from those of other pollutants. The last element of the production function is labor. The coefficients of the labor variables are positive and statistically significant at the 10% level in the Helsinki and Sofia models. Therefore, the positive effect of labor on emission reduction is identified in the Helsinki and Geneva models. On the contrary, human capital has no significant effect on economic performance in any of the models.

Overall, a positive effect of LRTAP on economic improvement is perceived only in the case of the Sofia Protocol, and the effects are highly significant at the 5% level. Since the empirical analysis about the effectiveness of LRTAP on economic performance has not been empirically estimated in previous studies, it is impossible to check the consistency with other quantitative analysis results. However, the results are in line with the result of the environmental effectiveness element in the present study. It is noteworthy that the Sofia

Protocol suggests that IEAs are effective in improving both environmental and economic performance.

3.6 Chapter Conclusions

This chapter aimed to quantitatively evaluate the effectiveness of IEAs from two perspectives for sustainable development (environmental and economic). In order to conduct the impact evaluation methodologies, four protocols of LRTAP (the Helsinki, Sofia, Oslo, and Geneva Protocols) were initially targeted for the analysis. For this purpose, based on participating countries of the Geneva Convention in 1979, which is the foundation convention of each LRTAP protocol, the national data on the reduction status of pollutants subjected to regulation, social-economic conditions, such as population and GDP, and ratification status, were collected. Then, four country-based panel data sets of each protocol were established and used for the empirical analysis.

In order to compare the non-participating countries and participating countries appropriately, the samples of both populations were selected by the PSM method first, and the DID analysis of before and after the protocol was carried out. To increase the statistical robustness of the results as compared to previous studies, this study adopted the advanced impact evaluation technique that combines the PSM and DID methods. As a result, the effectiveness of IEAs was evaluated more precisely, and the statistical reliability of the results was verified by reviewing associated theoretical debates about the effectiveness of LRTAP.

In addition, most existing studies have targeted the early stages of protocols on SO_X, and NO_X (the Helsinki and Sofia Protocols), while this study also adopted protocols aimed to regulate the NMVOC (the Geneva Protocol) and a relatively new protocol for SO_X (the Oslo Protocol). Although the research objects of this chapter were still within the LRTAP framework, it is considered that it could be analyzed from a more comprehensive view; this is one of the contributions of the present paper to the field of IEA study.

In the context of controversial arguments among scholars, the empirical results of this chapter reveal that the environmental and economic effectiveness trends differ depending upon the characteristics of each LRTAP protocol. In detail, the analysis results of the three protocols exclusive of the Sofia Protocol demonstrate that the environmental quality of the member countries has not improved significantly even though they participated in protocols intended to improve environmental performance. The results of the economic effectiveness model show that only the Sofia Protocol had a positive effect on economic performance in member countries, and these results are consistent with the empirical findings of the environmental effectiveness model. Moreover, from the control variables (population, GDP) and the production function elements, the results of the Sofia Protocol are found to be contradictory with those of other protocols.

Overall, based on the empirical results in this chapter, the existence of an IEA that has a positive effect on both environmental and economic performance is perceived. Furthermore, it is considered that the characteristics of various contaminants should be taken into account when establishing and evaluating the effectiveness of IEAs. However, it is difficult to generalize the results about the effectiveness of LRTAP for the effectiveness of IEAs. This is because the research objects of this chapter, the protocols of LRTAP, concentrate upon transboundary air pollution in continental Europe, and participant countries are mainly European countries. Moreover, LRTAP is one of the traditional IEAs that has no consideration for the negative impact on the economies of member countries. Thus, further research about the effectiveness of IEAs is required that takes account of costs caused by the implementation of a protocol and covers more extensive nations.

The next chapter investigates the impact of the Kyoto Protocol on environmental performance and economic improvement to perceive whether IEAs that contain market-based mechanisms with the principle of "common but differentiated responsibilities" have a positive effect on emission reduction in line with economic improvement. Subsequently, prediction based on the empirical results is conducted for estimating expected emission reduction and economic burden.

3.7 Chapter Acknowledgment

This study is supported by Waseda University Global COE Program, “Global Institute for Asian Regional Integration” (FY2007–FY2011).

Appendix 3.1 Status of Ratification of 1979 Convention on LRTAP

Participant	Signature	Ratification, Acceptance (A), Approval (AA), Accession (a), Succession (d)
Albania		2 Dec 2005 a
Armenia		21 Feb 1997 a
Austria	13 Nov 1979	16 Dec 1982
Azerbaijan		3 Jul 2002 a
Belarus	14 Nov 1979	13 Jun 1980
Belgium	13 Nov 1979	15 Jul 1982
Bosnia and Herzegovina [2]		1 Sep 1993 d
Bulgaria	14 Nov 1979	9 Jun 1981
Canada	13 Nov 1979	15 Dec 1981
Croatia [2]		21 Sep 1992 d
Cyprus		20 Nov 1991 a
Czech Republic [3]		30 Sep 1993 d
Denmark	14 Nov 1979	18 Jun 1982
Estonia		7 Mar 2000 a
European Union	14 Nov 1979	15 Jul 1982 AA
Finland	13 Nov 1979	15 Apr 1981
France	13 Nov 1979	3 Nov 1981 AA
Georgia		11 Feb 1999 a
Germany [4, 5]	13 Nov 1979	15 Jul 1982
Greece	14 Nov 1979	30 Aug 1983
Holy See	14 Nov 1979	
Hungary	13 Nov 1979	22 Sep 1980
Iceland	13 Nov 1979	5 May 1983
Ireland	13 Nov 1979	15 Jul 1982
Italy	14 Nov 1979	15 Jul 1982
Kazakhstan		11 Jan 2001 a
Kyrgyzstan		25 May 2000 a
Latvia		15 Jul 1994 a
Liechtenstein	14 Nov 1979	22 Nov 1983
Lithuania		25 Jan 1994 a
Luxembourg	13 Nov 1979	15 Jul 1982
Malta		14 Mar 1997 a

Monaco		27 Aug 1999 a
Montenegro [6]		23 Oct 2006 d
Netherlands [7]	13 Nov 1979	15 Jul 1982 A
Norway	13 Nov 1979	13 Feb 1981
Poland	13 Nov 1979	19 Jul 1985
Portugal	14 Nov 1979	29 Sep 1980
Republic of Moldova		9 Jun 1995 a
Romania	14 Nov 1979	27 Feb 1991
Russian Federation	13 Nov 1979	22 May 1980
San Marino	14 Nov 1979	
Serbia [2]		12 Mar 2001 d
Slovakia [3]		28 May 1993 d
Slovenia [2]		6 Jul 1992 d
Spain	14 Nov 1979	15 Jun 1982
Sweden	13 Nov 1979	12 Feb 1981
Switzerland	13 Nov 1979	6 May 1983
The former Yugoslav Republic of Macedonia [2]		30 Dec 1997 d
Turkey	13 Nov 1979	18 Apr 1983
Ukraine	14 Nov 1979	5 Jun 1980
United Kingdom of Great Britain and Northern Ireland [8]	13 Nov 1979	15 Jul 1982
United States of America	13 Nov 1979	30 Nov 1981

Source: United Nations Treaty Collection (UNTC) (n.d.).

Note: 1. The date of 16 March 1983 has been retained on the basis of the English and Russian authentic texts of article 16 (1) (". . . on the ninetieth day after the date of deposit of the twenty-fourth instrument."), which differ in that respect from the French text (". . . le quatre-vingt-dixième jour à compter de la date de dépôt . . .") but are more in accordance with the computation method generally used for multilateral treaties deposited with the Secretary-General.

2. The former Yugoslavia had signed and ratified the Convention on 13 November 1979 and 18 March 1987 respectively. See also note 1 under "Bosnia and Herzegovina", "Croatia", "former Yugoslavia", "Slovenia", "The Former Yugoslav Republic of Macedonia" and "Yugoslavia" in the "Historical Information" section in the front matter of this volume.

3. Czechoslovakia had signed and ratified the Convention on 13 November 1979 and 23 December 1983, respectively. See also note 1 under "Czech Republic" and note 1 under "Slovakia" in the "Historical Information" section in the front matter of this volume.

4. See note 1 under "Germany" regarding Berlin (West) in the "Historical Information" *section in the front matter of this volume.*

5. *The German Democratic Republic had signed and ratified the Convention on 13 November 1979 and 7 June 1982, respectively. See also note 2 under "Germany" in the "Historical Information" section in the front matter of this volume.*
6. *See note 1 under "Montenegro" in the "Historical Information" section in the front matter of this volume.*
7. *For the Kingdom in Europe.*
8. *Including the Bailiwick of Jersey, the Bailiwick of Guernsey, the Isle of Man, Gibraltar, the United Kingdom Sovereign Base Areas of Akrotiri and Dhekhelia in the island of Cyprus.*

Appendix 3.2 Brief information on each protocol of LRTAP

Year	Protocols
1999	**Protocol to Abate Acidification, Eutrophication and Ground-level Ozone**
	The Executive Body adopted the Protocol to Abate Acidification, Eutrophication and Ground-level Ozone in Gothenburg (Sweden) on 30 November 1999. The Protocol sets emission ceilings for 2010 for four pollutants: sulphur, NO_X, VOCs and ammonia. These ceilings were negotiated on the basis of scientific assessments of pollution effects and abatement options. Parties whose emissions have a more severe environmental or health impact and whose emissions are relatively cheap to reduce will have to make the biggest cuts. Once the Protocol is fully implemented, Europe's sulphur emissions should be cut by at least 63%, its NO_X emissions by 41%, its VOC emissions by 40% and its ammonia emissions by 17% compared to 1990. The Protocol also sets tight limit values for specific emission sources (e.g. combustion plant, electricity production, dry cleaning, cars and lorries) and requires best available techniques to be used to keep emissions down. VOC emissions from such products as paints or aerosols will also have to be cut. Finally, farmers will have to take specific measures to control ammonia emissions. Guidance documents adopted together with the Protocol provide a wide range of abatement techniques and economic instruments for the reduction of emissions in the relevant sectors, including transport. The Protocol was amended in 2012 to include national emission reduction commitments to be achieved in 2020 and beyond. Several of the Protocol's technical annexes were revised with updated sets of emission limit values for both key stationary sources and mobile sources, as well as with emission ceilings for fine particulate matter. The revised Protocol also introduced flexibilities to facilitate accession of new Parties, mainly countries in Southern and Eastern Europe, the Caucasus and Central Asia.
1998	**Protocol on Persistent Organic Pollutants (POPs)**
	The Executive Body adopted the Protocol on Persistent Organic Pollutants on 24 June 1998 in Aarhus (Denmark). It focuses on a list of 16 substances that have been singled out according to agreed risk criteria. The substances comprise eleven pesticides, two industrial chemicals and three by-products/contaminants. The ultimate objective is to eliminate any discharges, emissions and losses of POPs. The Protocol bans the production and use of some products outright (aldrin, chlordane, chlordecone, dieldrin, endrin, hexabromobiphenyl, mirex and toxaphene). Others are scheduled for elimination at a later stage (DDT, heptachlor, hexaclorobenzene, PCBs). Finally, the Protocol severely restricts the use of DDT, HCH (including lindane) and PCBs. The Protocol includes provisions for dealing with the wastes of products that will be banned. It also

	obliges Parties to reduce their emissions of dioxins, furans, PAHs and HCB below their levels in 1990 (or an alternative year between 1985 and 1995). For the incineration of municipal, hazardous and medical waste, it lays down specific limit values. On 18 December 2009, Parties to the Protocol on POPs adopted decisions 2009/1, 2009/2 and 2009/3 to amend the Protocol to include seven new substances: hexachlorobutadiene, octabromodiphenyl ether, pentachlorobenzene, pentabromodiphenyl ether, perfluorooctane sulfonates, polychlorinated naphthalenes and short-chain chlorinated paraffins. Furthermore, the Parties revised obligations for DDT, heptachlor, hexachlorobenzene and PCBs as well as emission limit values (ELVs) from waste incineration. Parallel to this, with a view to facilitating the Protocol's ratification by countries with economies in transition, the Parties introduced flexibility for these countries regarding the time frames for the application of ELVs and best available technologies (BAT). Finally, the Parties adopted decision 2009/4 to update guidance on BAT to control emissions of POPs in annex V and turn parts of it into a guidance document (ECE/EB.AIR/2009/14). These amendments have not yet entered into force for the Parties that adopted them.
1998	**Protocol on Heavy Metals**
	The Executive Body adopted the Protocol on Heavy Metals on 24 June 1998 in Aarhus (Denmark). It targets three particularly harmful metals: cadmium, lead and mercury. According to one of the basic obligations, Parties will have to reduce their emissions for these three metals below their levels in 1990 (or an alternative year between 1985 and 1995). The Protocol aims to cut emissions from industrial sources (iron and steel industry, non-ferrous metal industry), combustion processes (power generation, road transport) and waste incineration. It lays down stringent limit values for emissions from stationary sources and suggests best available techniques (BAT) for these sources, such as special filters or scrubbers for combustion sources or mercury-free processes. The Protocol requires Parties to phase out leaded petrol. It also introduces measures to lower heavy metal emissions from other products, such as mercury in batteries, and proposes the introduction of management measures for other mercury-containing products, such as electrical components (thermostats, switches), measuring devices (thermometers, manometers, barometers), fluorescent lamps, dental amalgam, pesticides and paint. The Protocol was amended in 2012, to adopt more stringent controls of heavy metals emissions and introduce flexibilities to facilitate accession of new Parties, notably countries in Eastern Europe, the Caucasus and Central Asia.
1994	**Protocol on Further Reduction of Sulphur Emissions**
	The 1994 Oslo Protocol on Further Reduction of Sulphur Emissions entered into force on

	5 August 1998. An effects-based approach, the critical load concept, best available technology, energy savings, the application of economic instruments and other considerations was applied in the preparation of the Protocol. This has led to a differentiation of emission reduction obligations of Parties to the Protocol. The effects-based approach, which aims at gradually attaining critical loads, sets long-term targets for reductions in sulphur emissions, although it has been recognized that critical loads will not be reached in one single step. An important new feature was introduced in connection with the adoption of the new Sulphur Protocol and recently updated, namely a decision on the structure and functions of an Implementation Committee, as well as procedures for its review of compliance. The Committee, consisting of eight Parties, shall analyze and evaluate on a periodic basis information related to compliance with Parties' obligations with a view to securing constructive solutions in case of non-compliance. The secretariat will be called upon to provide input for this process.
1991	**Protocol concerning the Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes**
	In November 1991, the Protocol to the Convention on Long-range Transboundary Air Pollution on the Control of Emissions of Volatile Organic Compounds (VOCs, i.e. hydrocarbons) or Their Transboundary Fluxes, the second major air pollutant responsible for the formation of ground level ozone, was adopted. It has entered into force on 29 September 1997. This Protocol specifies three options for emission reduction targets that have to be chosen upon signature or upon ratification: (i) 30% reduction in emissions of volatile organic compounds (VOCs) by 1999 using a year between 1984 and 1990 as a basis. (This option has been chosen by Austria, Belgium, Estonia, Finland, France, Germany, Netherlands, Portugal, Spain, Sweden and the United Kingdom with 1988 as base year, by Denmark with 1985, by Liechtenstein, Switzerland and the United States with 1984, and by Czech Republic, Italy, Luxembourg, Monaco and Slovakia with 1990 as base year); (ii) The same reduction as for (i) within a Tropospheric Ozone Management Area (TOMA) specified in annex I to the Protocol and ensuring that by 1999 total national emissions do not exceed 1988 levels. (Annex I specifies TOMAs in Norway (base year 1989) and Canada (base year 1988)); (iii) Finally, where emissions in 1988 did not exceed certain specified levels, Parties may opt for a stabilization at that level of emission by 1999. (This has been chosen by Bulgaria, Greece, and Hungary).
1988	**Protocol concerning the Control of Nitrogen Oxides or their Transboundary Fluxes**

	In 1988 the Protocol concerning the Control of Emissions of Nitrogen Oxides or their Transboundary Fluxes was adopted in Sofia (Bulgaria). This Protocol requires as a first step, to freeze emissions of nitrogen oxides or their transboundary fluxes. The general reference year is 1987 (with the exception of the United States that chose to relate its emission target to 1978). Taking the sum of emissions of Parties to the NO_X Protocol in 1994, or a previous year, where no recent data are available, also a reduction of 9% compared to 1987 can be noted. Nineteen of the 25 Parties to the 1988 NO_X Protocol have reached the target and stabilized emissions at 1987 (or in the case of the United States 1978) levels or reduced emissions below that level according to the latest emission data reported. The second step to the NO_X Protocol requires the application of an effects-based approach. Applying the multi-pollutant, multi-effect critical load approach, a new instrument being prepared at present should provide for further reduction of emissions of nitrogen compounds, including ammonia, and volatile organic compounds, in view of their contribution to photochemical pollution, acidification and eutrophication, and their effects on human health, the environment and materials, by addressing all significant emission sources. The collection of scientific and technical information as a basis for a further reduction in nitrogen oxides and ammonia, considering their acidifying as well as nitrifying effects, is under way.
1985	**Protocol on the Reduction of Sulphur Emissions or their Transboundary Fluxes by at least 30 %**
	The Protocol to the Convention on Long-range Transboundary Air Pollution on the Reduction of Sulphur Emissions or their Transboundary Fluxes by at least 30 % was entered into force in 1987. Twenty-one ECE countries are Parties to this Protocol, which aims at abating one of the major air pollutants. As a result of this Protocol, substantial cuts in sulphur emissions have been recorded in Europe: Taken as a whole, the 21 Parties to the 1985 Sulphur Protocol reduced 1980 sulphur emissions by more than 50% by 1993 (using the latest available figure, where no data were available for 1993). Also individually, based on the latest available data, all Parties to the Protocol have reached the reduction target. Eleven Parties have achieved reductions of at least 60%. Given the target year 1993 for the 1985 Sulphur Protocol, it can be concluded that all Parties to that Protocol have reached the target of reducing emissions by at least 30%.
1984	**Protocol on Long-term Financing of the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP)**
	The Protocol to the Convention on Long-range Transboundary Air Pollution on the

	Financing of the Co-operative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP) was entered into force in 1988. Fourty-four ECE countries are currently Parties to this Protocol. It is an instrument for international cost-sharing of a monitoring programme which forms the backbone for review and assessment of relevant air pollution in Europe in the light of agreements on emission reduction. EMEP has three main components: collection of emission data for SO_2, NO_X, VOCs and other air pollutants; measurement of air and precipitation quality; and modeling of atmospheric dispersion. At present, about 100 monitoring stations in 24 ECE countries participate in the programme.

Source: UNECE (n.d.).

Appendix 3.3 Status of Participants of LRTAP and Research Objects of Previous Studies

Countries	LRTAP				Previous studies				EU
IEA/Studies (Adoption year)	**Helsinki Protocol (1985)**	**Sofia Protocol (1988)**	**Geneva Protocol (1991)**	**Oslo Protocol (1994)**	**Murdoch et al. (1997)**	**Helm and Sprinz (2000)**	**Ringquist and Kostadinova (2005)**	**Aakvik and Tjøtta (2011)**	
Pollutants /Scope	SO_2	NO_X	NMVOC	SO_2	Helsinki Sofia	Helsinki Sofia	Helsinki	Helsinki Oslo	
Entry into force /Research periods	1987	1991	1997	1998	1980–1990	1980–1993 1987–1994	1980–1994	1960–2002	
Number of countries	22	29	26	27	23	25	20	25 (30)	27
Austria	O	O	O	O	O	O	O	O	O
Belarus	O	O	X	X	X	O	X	X	X
Belgium	O	O	O	O	O	O	O	O	O
Bulgaria	O	O	O	O	X	O	O	O	O
Canada	O	O	O	O	X	X	X	X	X
Croatia	X	X	X	O	X	X	X	X	X
Cyprus	X	O	X	X	X	X	X	X	O
Czech Republic	O	O	O	O	O	O	O (Czechoslovakia)	O (Czechoslovakia)	O
Denmark	O	O	O	O	O	O	O	O	O
Estonia	O	O	O	X	X	X	X	X	O
Finland	O	O	O	O	O	O	O	O	O
France	O	O	O	X	O	O	O	O	O

Germany	O	O	O	O	O (East, West)	O	O (West)	O (East, West)	O
Greece	X	O	O	O	O	O (no NO_X)	X	O	O
Hungary	O	O	O	O	O	O	O	O	O
Iceland	X	X	X	X	X	X	X	O	X
Ireland	X	O	X	O	O	O	O	O	O
Italy	O	O	O	O	O	O	O	O	O
Latvia	X	X	X	X	X	X	X	X	O
Liechtenstein	O	O	O	O	X	X	X	X	X
Lithuania	X	X	X	X	X	X	X	X	O
Luxembourg	O	O	O	O	O	X	X	X	O
Monaco	X	X	O	O	X	X	X	X	X
Malta	X	X	X	X	X	X	X	X	O
Netherlands	O	O	O	O	O	O	O	O	O
Norway	O	O	O	O	O	O	O	O	X
Poland	X	O	X	O	O	O	O	O	O
Portugal	X	X	O	X	O	O	O	O	O
Romania	X	X	X	X	O	O	X	O	O
Russian Federation	O	O	X	O	O (Soviet Union)	O	X	O (Soviet Union)	X
Slovakia	O	O	O	O	X	X	O (Czechoslovakia)	O (Czechoslovakia)	O
Slovenia	X	X	X	O	X	X	X	X	O

Spain	X	O	O	O	O	O	O	O	O
Sweden	O	O	O	O	O	O	O	O	O
Switzerland	O	O	O	O	O	O	O	O	X
Turkey	X	X	X	X	X	X	X	O	X
Ukraine	O	O	O	O	X	O	X	X	X
UK	X	O	O	O	O	O	O	O	O
USA	X	O	O	X	X	X	X	X	X
Yugoslavia	X	X	X	X	O	O	X	X	X

Source: Author.

Appendix 3.4 Logical Basis of the Target Year from Articles of Protocols

Protocol		**Article**
Helsinki Protocol	Article 2	*The Parties shall reduce their national annual sulphur emissions or their transboundary fluxes by at least 30 % as soon as possible and at the latest by 1993, using 1980 levels as the basis for calculation of reductions*
Sofia Protocol	Article 2.1	*The Parties shall, as soon as possible and as a first step, take effective measures to control and/or reduce their national annual emissions of nitrogen oxides or their transboundary fluxes so that these, at the latest by 31 December 1994, do not exceed their national annual emissions of nitrogen oxides or transboundary fluxes of such emissions for the calendar year 1987 or any previous year to be specified upon signature of, or accession to, the Protocol, provided that in addition, with respect to any Party specifying such a previous year, its national average annual transboundary fluxes or national average annual emissions of nitrogen oxides for the period from 1 January 1987 to 1 January 1996 do not exceed its transboundary fluxes or national emissions for the calendar year 1987*
Oslo Protocol	Article 2.5 (b)	*No later than 1 July 2004 apply, as far as possible without entailing excessive costs, emission limit values at least as stringent as those specified in annex V to those major existing stationary combustion sources the thermal input of which is above 500 MWth taking into account the remaining lifetime of a plant, calculated from the date of entry into force of the present Protocol, or apply equivalent emission limitations or other appropriate provisions, provided that these achieve the sulphur emission ceilings specified in annex II and, subsequently, further approach the critical loads as given in annex I; and no later than 1 July 2004 apply emission limit values or emission limitations to those major existing stationary combustion sources the thermal input of which is between 50 and 500 MWth using annex V as guidance*
	Article 2.5 (c)	*No later than two years after the date of entry into force of the present Protocol apply national standards for the sulphur content of gas oil at least as stringent as those specified in annex V. In cases where the supply of gas oil cannot otherwise be ensured, a State may extend the time period given in this subparagraph to a period of to ten years. In this case it shall specify, in a declaration to be deposited together with the instrument of ratification, acceptance, approval or accession, its intention to extend the*

		time period
Geneva Protocol	Article 2.1 (a)	*It shall, as soon as possible and as a first step, take effective measures to reduce its national annual emissions of VOCs by at least 30 % by the year 1999, using 1988 levels as a basis or any other annual level during the period 1984 to 1990, which it may specify upon signature of or accession to the present Protocol*

Source: UNECE (n.d.).

Appendix 3.5 Status of Ratification of the Helsinki Protocol

Participant	Signature	Ratification, Acceptance (A), Approval (AA), Accession (a), Succession (d)
Albania		16 Jun 2009 a
Austria	9 Jul 1985	4 Jun 1987
Belarus	9 Jul 1985	10 Sep 1986 A
Belgium	9 Jul 1985	9 Jun 1989
Bulgaria	9 Jul 1985	26 Sep 1986 AA
Canada	9 Jul 1985	4 Dec 1985
Czech Republic [1]		30 Sep 1993 d
Denmark	9 Jul 1985	29 Apr 1986
Estonia		7 Mar 2000 a
Finland	9 Jul 1985	24 Jun 1986
France	9 Jul 1985	13 Mar 1986 AA
Germany [2, 3]	9 Jul 1985	3 Mar 1987
Hungary	9 Jul 1985	11 Sep 1986
Italy	9 Jul 1985	5 Feb 1990
Liechtenstein	9 Jul 1985	13 Feb 1986
Lithuania		15 Mar 2007 a
Luxembourg	9 Jul 1985	24 Aug 1987
Netherlands [4]	9 Jul 1985	30 Apr 1986 A
Norway	9 Jul 1985	4 Nov 1986
Russian Federation	9 Jul 1985	10 Sep 1986 A
Slovakia [1]		28 May 1993 d
Sweden	9 Jul 1985	31 Mar 1986
Switzerland	9 Jul 1985	21 Sep 1987
The former Yugoslav Republic of Macedonia		10 Mar 2010 a
Ukraine	9 Jul 1985	2 Oct 1986 A

Source: UNTC (n.d.).

Note: 1. Czechoslovakia had signed and approved the Protocol on 9 July 1985 and 26 November 1986, respectively. See also note 1 under "Czech Republic" and note 1 under "Slovakia" in the "Historical Information" section in the front matter of this volume.

2. See note 1 under "Germany" regarding Berlin (West) in the "Historical Information" section in the front matter of this volume.

3. The German Democratic Republic had signed and approved the Protocol on 9 July 1985 and

26 November 1986, respectively. See also note 2 under "Germany" in the "Historical Information" section in the front matter of this volume.

4. For the Kingdom in Europe.

Appendix 3.6 Status of Ratification of the Sofia Protocol

Participant	Signature	Ratification, Acceptance (A), Approval (AA), Accession (a), Succession (d)
Albania		16 Jun 2009 a
Austria	1 Nov 1988	15 Jan 1990
Belarus	1 Nov 1988	8 Jun 1989 A
Belgium	1 Nov 1988	8 Nov 2000
Bulgaria	1 Nov 1988	30 Mar 1989
Canada	1 Nov 1988	25 Jan 1991
Croatia		3 Mar 2008 a
Cyprus		2 Sep 2004 a
Czech Republic [1]		30 Sep 1993 d
Denmark [2]	1 Nov 1988	1 Mar 1993 A
Estonia		7 Mar 2000 a
European Union		17 Dec 1993 a
Finland	1 Nov 1988	1 Feb 1990
France	1 Nov 1988	20 Jul 1989 AA
Germany [3]	1 Nov 1988	16 Nov 1990
Greece	1 Nov 1988	29 Apr 1998
Hungary	3 May 1989	12 Nov 1991 AA
Ireland	1 May 1989	17 Oct 1994
Italy	1 Nov 1988	19 May 1992
Liechtenstein	1 Nov 1988	24 Mar 1994
Lithuania		26 May 2006 a
Luxembourg	1 Nov 1988	4 Oct 1990
Netherlands [4]	1 Nov 1988	11 Oct 1989 A
Norway	1 Nov 1988	11 Oct 1989
Poland	1 Nov 1988	23 Nov 2011
Russian Federation	1 Nov 1988	21 Jun 1989 A
Slovakia [1]		28 May 1993 d
Slovenia		5 Jan 2006 a
Spain	1 Nov 1988	4 Dec 1990
Sweden	1 Nov 1988	27 Jul 1990
Switzerland	1 Nov 1988	18 Sep 1990
The former Yugoslav Republic of		10 Mar 2010 a

Macedonia		
Ukraine	1 Nov 1988	24 Jul 1989 A
United Kingdom of Great Britain and Northern Ireland [5]	1 Nov 1988	15 Oct 1990
United States of America	1 Nov 1988	13 Jul 1989 A

Source: UNTC (n.d.)

Note: 1. Czechoslovakia had signed and approved the Protocol on 1 November 1988 and 17 August 1990, respectively. See also note 1 under "Czech Republic" and note 1 under "Slovakia" in the "Historical Information" section in the front matter of this volume.

2.With a declaration of non-application to the Faroe Islands and Greenland.

3.The German Democratic Republic had signed the Protocol on 1 November 1988. See also note 2 under "Germany" in the "Historical Information" section in the front matter of this volume.

4.For the Kingdom in Europe.

5.The instrument specifies that the said Protocol is ratified in respect of the United Kingdom of Great Britain and Northern Ireland, the Bailiwick of Jersey, the Bailiwick of Guernsey, the Isle of Man and the Sovereign Base Areas of Akrotiri and Dhekelia in the island of Cyprus.

Appendix 3.7 Status of Ratification of the Geneva Protocol

Participant	Signature	Ratification, Acceptance (A), Approval (AA), Accession (a)
Austria	19 Nov 1991	23 Aug 1994
Belgium	19 Nov 1991	8 Nov 2000
Bulgaria	19 Nov 1991	27 Feb 1998
Canada	19 Nov 1991	
Croatia		3 Mar 2008 a
Czech Republic		1 Jul 1997 a
Denmark [1]	19 Nov 1991	21 May 1996 A
Estonia		7 Mar 2000 a
European Union	2 Apr 1992	
Finland	19 Nov 1991	11 Jan 1994 A
France	19 Nov 1991	12 Jun 1997 AA
Germany	19 Nov 1991	8 Dec 1994
Greece	19 Nov 1991	
Hungary	19 Nov 1991	10 Nov 1995
Italy	19 Nov 1991	30 Jun 1995
Liechtenstein	19 Nov 1991	24 Mar 1994
Lithuania		22 May 2007 a
Luxembourg	19 Nov 1991	11 Nov 1993
Monaco		26 Jul 2001 a
Netherlands [2]	19 Nov 1991	29 Sep 1993 A
Norway	19 Nov 1991	7 Jan 1993
Portugal	2 Apr 1992	
Slovakia		15 Dec 1999 a
Spain	19 Nov 1991	1 Feb 1994
Sweden	19 Nov 1991	8 Jan 1993
Switzerland	19 Nov 1991	21 Mar 1994
The former Yugoslav Republic of Macedonia		10 Mar 2010 a
Ukraine	19 Nov 1991	
United Kingdom of Great Britain and Northern Ireland [3]	19 Nov 1991	14 Jun 1994
United States of America	19 Nov 1991	

Source: UNTC (n.d.).

Note: 1. Upon signature, decision was reserved as concerns the application of the Protocol to the Faroe Islands and Greenland. Upon acceptance, the Government of Denmark declared that "This acceptance does not apply to the Faroe Islands and Greenland".

2.For the Kingdom in Europe.

3.Application to the United Kingdom of Great Britain and Northern Ireland, the Bailiwick of Guernsey, the Bailiwick of Jersey and the Isle of Man.

Appendix 3.8 Status of Ratification of the Oslo Protocol

Participant	Signature	Ratification, Accession (a), Acceptance (A), Approval (AA), Succession (d)
Austria	14 Jun 1994	27 Aug 1998
Belgium [3]	14 Jun 1994	8 Nov 2000
Bulgaria	14 Jun 1994	5 Jul 2005
Canada	14 Jun 1994	8 Jul 1997
Croatia	14 Jun 1994	27 Apr 1999 A
Cyprus		26 Apr 2006 a
Czech Republic	14 Jun 1994	19 Jun 1997
Denmark [4]	14 Jun 1994	25 Aug 1997 AA
European Union	14 Jun 1994	24 Apr 1998 AA
Finland	14 Jun 1994	8 Jun 1998 A
France	14 Jun 1994	12 Jun 1997 AA
Germany	14 Jun 1994	3 Jun 1998
Greece	14 Jun 1994	24 Feb 1998
Hungary	9 Dec 1994	11 Mar 2002
Ireland	17 Oct 1994	4 Sep 1998
Italy	14 Jun 1994	14 Sep 1998
Liechtenstein	14 Jun 1994	27 Aug 1997 A
Lithuania		22 Apr 2008 a
Luxembourg	14 Jun 1994	14 Jun 1996
Monaco		9 Apr 2002 a
Netherlands [5]	14 Jun 1994	30 May 1995 A
Norway	14 Jun 1994	3 Jul 1995
Poland	14 Jun 1994	
Russian Federation	14 Jun 1994	
Slovakia	14 Jun 1994	1 Apr 1998
Slovenia	14 Jun 1994	7 May 1998
Spain	14 Jun 1994	7 Aug 1997
Sweden	14 Jun 1994	19 Jul 1995
Switzerland	14 Jun 1994	23 Jan 1998
The former Yugoslav Republic of Macedonia		10 Mar 2010 a
Ukraine	14 Jun 1994	

United Kingdom of Great Britain and Northern Ireland [6]	14 Jun 1994	17 Dec 1996

Source: UNTC (n.d.).

Note: 1. In a letter dated 18 January 2002 and received on 12 March 2002, the Secretary to the Executive Body for the Convention on Long-range Transboundary Air Pollution, informed the Secretary-General that at its nineteenth session, the Executive Body adopted by consensus an adjustment to annex II to the Protocol necessary to enable Monaco's accession to the Protocol, agreeing to add its name, together with emission levels, sulphur emission ceilings and percentage emission reductions.In accordance with article 11 of the Protocol, the adoption of the adjustment will become effective on the ninetieth day following the date of the said letter, that is to say on 18 April 2002.Subsequently, in a letter dated 8 March 2005 and received on 14 March 2005, the Secretary to the Executive Body for the Convention on Long-range Transboundary Air Pollution, informed the Secretary-General that at its twenty-second session, the Executive Body adopted by consensus an adjustment to annex II to the Protocol necessary to enable Cyprus's accession to the Protocol, agreeing to add its name, together with emission levels, sulphur emission ceilings and percentage emission reductions.In accordance with article 11 of the Protocol, the adoption of the adjustment will become effective on the ninetieth day following the date of the said letter, that is to say on 12 May 2005.In a letter dated 18 March 2008 and received on 27 March 2008, the Secretary to the Executive Body for the Convention on Long-range Transboundary Air Pollution informed the Secretary-General that at its twenty-fifth session, the Executive Body adopted by consensus an adjustment to Annex II to the Protocol necessary to enable Lithuania's accession to the Protocol, agreeing to add its name, together with emission levels, emission ceilings and percentage emission reductions for sulphur.

2.United Nations, Resolutions of the Economic and Social Council, 4th session, 28-29 March 1942 (E/437), p. 10.

3.With a declaration to the effect that this signature also commits the Flemish region, the Wallone region and the region of the capital Brussels.

4.With reservation for the application to the Faroe Islands and Greenland.

5.For the Kingdom in Europe.

6.For the United Kingdom of Great Britain and Northern Ireland and the Bailiwick of Jersey. On 21 November 2003: for the Isle of Man.

Appendix 3.9 Descriptive Statistics of the Environmental Effectiveness Model

Variables	N	Mean	SD	Min	Max
The Helsinki Protocol					
SO_X (Stern)	67	782.109	1801.651	2.750	10581.380
Regime participation	67	0.284	0.454	0	1
Time dummy	67	0.567	0.499	0	1
Group dummy	67	0.537	0.502	0	1
Population	67	27099.040	47480.970	344.000	260000.000
GDP	67	4242.507	11805.400	13.000	75000.000
The Oslo Protocol					
SO_X (LRTAP)	64	945.267	2903.448	1.190	19365.100
Regime participation	64	0.328	0.473	0	1
Time dummy	64	0.484	0.504	0	1
Group dummy	64	0.641	0 .484	0	1
Population	64	24688.950	49919.510	266.000	290000.000
GDP	64	5585.000	16868.970	11.000	110000.000
The Sofia Protocol					
NO_X	66	1437.040	3831.819	5.540	21697.700
Regime participation	66	0.333	0.475	0	1
Time dummy	66	0.515	0.504	0	1
Group dummy	66	0.667	0.475	0	1
Population	66	31296.830	51236.420	381.850	270000.000
GDP	66	4705.273	13215.560	23.000	80000.000
The Geneva Protocol					
NMVOC	67	512.455	798.936	0.041	3185.750
Regime participation	67	0.254	0.438	0	1
Time dummy	67	0.507	0.504	0	1
Group dummy	67	0.493	0.504	0	1
Population	67	1554.0006	19791.070	387.000	82000.000
GDP	67	2506.075	4225.461	13.000	18000.000

Source: Author.

Appendix 3.10 Descriptive Statistics of the Economic Effectiveness Model

Variables	N	Mean	SD	Min	Max
The Helsinki Protocol					
GDP	46	5779.304	13900.000	13.000	75000.000
Regime participation	46	0.370	0.488	0	1
Time dummy	46	0.565	0.501	0	1
Group dummy	46	0.696	0.465	0	1
Labor (ILO)	46	13.588	24.844	0.137	120.259
Human capital	46	8.995	1.706	4.807	12.741
Capital	46	989.752	2191.762	1.995	11419.720
The Oslo Protocol					
GDP	59	5995.271	17517.440	11.000	110000.000
Regime participation	59	0.356	0.483	0	1
Time dummy	59	0.525	0.504	0	1
Group dummy	59	0.695	0.464	0	1
Labor (WDI)	59	12051.510	26244.370	142.594	150000.000
Human capital	59	9.988	1.458	6.444	13.190
Capital	59	1116.411	3158.265	1.609	20846.320
The Sofia Protocol					
GDP	66	4636.561	13235.240	10.000	80000.000
Regime participation	66	0.318	0.469	0	1
Time dummy	66	0.530	0.503	0	1
Group dummy	66	0.621	0.489	0	1
Labor (WDI)	66	14178.900	26192.680	137.762	140000.000
Human capital	66	9.116	1.341	6.039	12.741
Capital	66	849.805	2130.639	2.180	13104.830
The Geneva Protocol					
GDP	61	2616.770	4312.383	13.000	18000.000
Regime participation	61	0.279	0.452	0	1
Time dummy	61	0.525	0.504	0	1
Group dummy	61	0.541	0.502	0	1
Labor (WDI)	61	8420.396	10357.860	165.887	40000.000
Human capital	61	9.173	1.551	4.528	11.897
Capital	61	534.782	864.524	1.979	3945.943

Source: Author.

CHAPTER 4

Environmental and Economic Consequences of IEA: The Case of the Kyoto Protocol

This chapter investigates the effectiveness of the Kyoto Protocol on environmental performance and economic improvement using country-level panel data of 209 countries for the periods 1997–2008 and 2005–2008. This study combines the PSM and DID methods to examine two hypotheses. The first hypothesis tests the environmental effectiveness that perceives the effect of the protocol in terms of reducing CO_2 emission. This hypothesis is accepted, suggesting effective CO_2 emission reduction among Annex I Parties. In contrast, the second hypothesis that assumes the positive IEA effect on economic performance is rejected, indicating that participating in Annex I has a negative effect on the economic growth. However, from the prediction about the environmental and economic effectiveness based on the result of the statistical analysis, CO_2 emission reduction induced by the Kyoto Protocol exceeds the negative effect on GDP.

4.1 Introduction

Owing to the intensified environmental degradation, particularly in trans-boundary environmental problems, the need for establishing realistic and effective international instruments has arisen. Consequently, IEAs have been established as mechanisms for transnational cooperation to cope with global environmental degradation and to deal with environmental problems across nations. By participating in IEAs to achieve the common goal of protecting the environment, each country can go a step towards improving their environmental performance (Caldwell, 1990). Along with the proliferation of IEAs, studies that evaluate the effectiveness of IEAs have increased. However, due to the endemic nature of international policy, the effectiveness of IEAs is being questioned.

The Kyoto Protocol is one of the most influential IEAs with respect to the reduction of greenhouse gas (GHG) emissions, as it takes account of national differences in initial emissions, wealth, and capacity for change under the main principle of the 1992 United Nations Framework Convention on Climate Change (UNFCCC) (Grubb, 2004). To estimate its effectiveness, scholars have performed quantitative analysis using various methodologies and data, but the results obtained are still controversial. While proponents argue that the protocol has a significant effect on reducing emissions (Grunewald & Martínez-Zarzoso, 2009; Grunewald & Martínez-Zarzoso, 2011; UNFCCC, 2012), opponents claim that it rather an empty promise and its implementation incurs huge expenses (Böhringer, 2003; Böhringer et al., 2001; Huang et al., 2008; Kumazawa & Callaghan, 2012; Nordhaus & Boyer, 1999).

Furthermore, previous studies have mostly analyzed the environmental effectiveness aspect that studies the effect of an IEA in terms of how it eliminates or reduces environmental problems. Therefore, studies that consider economic performance on the participants along with the environmental effectiveness are lacking. Nevertheless, the Kyoto Protocol has tried to decrease the negative effect on economic performance with market-based mechanisms; there exists a possibility that supports the supposition that IEAs improve not only environmental but also economic performance (Golub et al., 2006; Manne & Richels, 1998).

Based on this assumption, this study posits two hypotheses on environmental performance and economic improvement. The first hypothesis investigates the protocol's effect on CO_2 emission reductions[19] and assumes that participating in Annex I of the Kyoto Protocol contributes to a reduction of CO_2 emissions. The second hypothesis predicts that there will be no adverse effects on the economic performance of parties in Annex I.

To test these hypotheses, this study combines the PSM and DID methods to analyze the environmental and economic effectiveness of the Kyoto Protocol from the time of its adoption and entry into force, to its target year. This technique allows this chapter to compare the environmental and economic performance of the non-Annex I countries to those of Annex I countries while controlling for unobserved internal and external analyst effect. It is largely expected that through the application of impact evaluation methods to the IEA study, a deeper and more precise understanding of the effectiveness of IEAs will be gained.

The findings of this study differ somewhat from expectations. While the results provide a robust empirical support for the first hypothesis, they do not support the second hypothesis. In other words, the Kyoto Protocol has a positive effect on CO_2 emission reduction, but does not seem to help improve economic growth. Instead, participating in Annex I protocol has a negative effect on GDP.

The remainder of the chapter is organized as follows: The following section begins by providing a theoretical framework on the effectiveness of the Kyoto Protocol and

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[19] Kim et al. (2012) indicate that a well-designed IEA can improve environmental performance.

establishing hypotheses about its environmental and economic aspects. Section 4.3 describes the data and specifies the methods employed in this chapter. As the previous chapter has defined and presented the impact evaluation technique combining the PSM and DID methods in detail, this section focuses on the specific models and two-time-period setting of this chapter. The empirical results of the environmental and economic effectiveness of the Kyoto Protocol and the predictions based on regression results are presented in Section 4.4, and the final section concludes this chapter.

4.2 The Kyoto Protocol: Effectiveness Issues and Hypotheses

This section provides a theoretical basis for the effectiveness of the Kyoto Protocol and establishes hypotheses based on the previous literature. First, it is necessary to draw on brief information on the Kyoto Protocol and discussions about the effectiveness of IEAs. Since then, upon developing the hypotheses about its effectiveness, specific focus can be placed upon the Kyoto Protocol.

The Kyoto Protocol is an international agreement affiliated with the UNFCCC that was adopted in December 1997 in Kyoto, and came into force in February 2005. Its first commitment period started in 2008 and ended in 2012. After that, in the Doha Amendment in 2012, new commitments for Annex I Parties were decided in the second commitment period from January 1, 2013 to December 31, 2020. Figure 4.1 presents the member countries of the

Kyoto Protocol. According to the homepage of the UNFCCC (UNFCCC, n.d.), there are 192 Parties[20] to the Kyoto Protocol of the UNFCCC. Appendix 4.1 proposes the specific status of participants of the Kyoto Protocol.

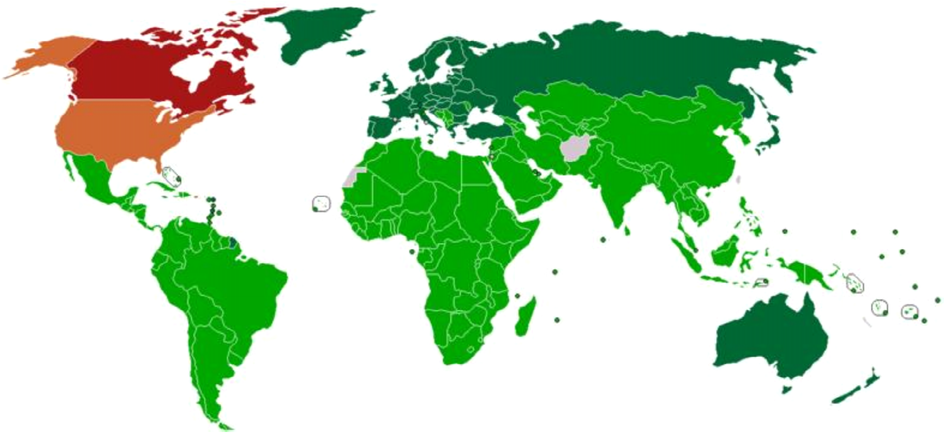

Figure 4.1 **Member Countries of the Kyoto Protocol**

Source: Wikipedia (n.d.).

Note: *Parties: Annex I and II countries with binding targets.*
Parties: Developing countries without binding targets.
States not Party to the Protocol.
Signatory country with no intention to ratify the treaty, with no binding targets.
Countries that have renounced the Protocol, with no binding targets.
Parties with no binding targets in the second period, which previously had targets.

This protocol admits that developed countries are mainly responsible for the high levels of GHG emissions so far. Therefore, internationally binding emission reduction targets were set that imposed a heavier burden on Annex I Parties[21] under the principle of "common

[20] These include 191 States and EU.

[21] Australia, Austria, Belarus, Belgium, Bulgaria, Canada, Croatia, Cyprus, Czech Republic, Denmark, Estonia, European Union, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia.

but differentiated responsibilities". In the first commitment period, they have a responsibility for meeting at least 55 % of the total CO_2 emissions for 1990. Article of the Kyoto Protocol makes their emission reduction duty quite clear:

> The Parties included in Annex I shall, individually or jointly, ensure that their aggregate anthropogenic carbon dioxide equivalent emissions of the greenhouse gases listed in Annex A do not exceed their assigned amounts, calculated pursuant to their quantified emission limitation and reduction commitments inscribed in Annex B and in accordance with the provisions of this Article, with a view to reducing their overall emissions of such gases by at least 5 per cent below 1990 levels in the commitment period 2008 to 2012. (Article 3)

What is unique about this protocol is that three market-based mechanisms have been offered to meet their emission reduction target. These flexible mechanisms: International Emissions Trading, Clean Development Mechanism (CDM), and Joint Implementation (JI), assist Annex I countries to meet their reduction obligations in a cost-effective way (de Chazournes, 1998). Paterson (2008) who claims about global governance for sustainable capitalism adduces the Kyoto Protocol as an example of global governance for sustainable perspective:

Liechtenstein, Lithuania, Luxembourg, Malta, Monaco, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation , Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom of Great Britain and Northern Ireland, United States of America (UNFCCC, n.d.).

> The climate change, as incarnated specifically in the Kyoto Protocol on Climate Change (1997) is perhaps the apogee of what I shall term global governance for sustainable capitalism. Key to Kyoto are three highly innovative mechanisms—emission trading, Joint Implementation (JI) and the Clean Development Mechanism (CDM). Collectively, these are now being referred to as the carbon market. (p. 110)

Based on the theoretical discussions of the IEAs' effectiveness in a framework of the Porter Hypothesis that provides a clue of theoretical potential that the environmental effectiveness of IEAs can be connected to the economic effectiveness, the two-dimensional effectiveness of the Kyoto Protocol can be formulated by reviewing previous studies. Therefore, the empirical models also focus on two hypotheses: The first aspect of effectiveness is the environmental effectiveness, which is estimated by the changes of environmental performance. In the case of the Kyoto Protocol, the level of CO2 emission reduction is the key standard of judgment because of data availability and its significant impact on global warming.

Indeed, some results of empirical testing have raised questions about the actual effectiveness of the Kyoto Protocol. Böhringer (2003) questions the effectiveness of the Kyoto Protocol, believing it to be a merely symbolic policy. He assesses the potential performance of the protocol and insists that there is no distinct emission reduction in the initial commitment period. However, he concludes that, although there is no significant effective emission reduction in the first commitment period, the ratification of the Kyoto Protocol is crucial for the continuation of the policy process of climate protection.

Some studies that have showed the lack of effectiveness of political agreements in reducing emissions argue that the underlying main driving factors of CO_2 emissions are industrialization. Kumazawa and Callaghan (2012) demonstrate that different emission reduction patterns are shown in the industrialized countries that are duty-bound to reduce CO_2 emissions. Huang et al. (2008) similarly argue that 38 industrialized countries are unable to meet their targets under the Kyoto Protocol within the specified time period.

On the other hand, arguments on the positive environmental effect of the Kyoto Protocol have indicated the decrease in CO_2 emissions. Considering the Kyoto Protocol and the CDM, Grunewald and Martínez-Zarzoso (2009) analyze the driving factors of CO_2 in terms of environmental regulations with a static and dynamic panel data model. They find that the obligations of the Kyoto Protocol have had a positive effect on reducing CO_2 emissions in both developed and developing countries. Their recent research that analyzes the driving factors of CO_2 emissions with a dynamic panel data model for the period 1960 to 2009 also reveals that the obligations of the Kyoto Protocol have had a reducing effect on CO_2 emissions (Grunewald & Martínez-Zarzoso, 2011). UNFCCC (2012), which investigates the national GHG emissions from 1990 to 2010, representatively examines the total aggregate

GHG emissions among Annex I countries and finds that it had decreased significantly. Specifically, 8.9 % of total GHG emission reductions are observed in all Annex I Parties. However, it is difficult to distinguish the effect of Kyoto Protocol, since this report focuses on estimating simple changes of reduction over 1990–2010.

In brief, the results from previous studies on the environmental effectiveness of the Kyoto Protocol are open to dispute. One of the major limitations of existing literature is that they fail to distinguish how the IEA effect controls the characteristics of each nation. In this regard, some scholars have indicated the intrinsic difficulties of predicting impacts, such as dealing with hypothetical situations or controlling external factors (Aakvik & Tjøtta, 2011; Frantzi, 2008; Underdal, 1992; Vollenweider, 2013). For example, socioeconomic status and the base level of pollutants differ from country to country; therefore, they have to consider in the quantitative analysis. Additionally, the IEA effect on emission reduction has already been analyzed in a previous study applying EKC theory, which is focused on the global trend of emission reduction, but not specifically on those countries participating in Annex I.

Therefore, there is a strong need to investigate more clearly the practical effect of the protocol on CO_2 emissions with proper models that can distinguish the effect of the agreements. As is shown by the results of Aakvik and Tjøtta (2011), Kim et al. (2012) and Vollenweider (2013), quantitative analysis can capture the precise effect of emission reductions. This motivates us to test the first hypothesis whether the Kyoto Protocol improves environmental performance or not.

Hypothesis 1: *Participating in Annex I of the Kyoto Protocol has a positive effect on the CO_2 emission reduction.*

Only a few studies have analyzed the effect of the Kyoto Protocol on national economic performance, or on other IEAs. As for the concerns over the cost of policy implementation, the existing empirical studies are skeptical about the economic effectiveness of the Kyoto Protocol. Nordhaus and Boyer (1999) conduct an economic analysis of the Kyoto Protocol and claim that the emissions policy is highly cost inefficient, as the net global cost of the protocol reached approximately 716 billion dollars in their analysis. Böhringer et al. (2001) also state that the spillover effects of carbon abatement in industrialized countries on developing countries are significant. Hence, despite the lack of developing country's reduction obligations, serious problems of fair burden sharing occur.

However, as a representative of the stringent and flexible international environmental policies inherent in market-based mechanisms, the Kyoto Protocol encourages decreasing the negative effects on economic growth. There are some evidences from empirical studies. For instance, Manne and Richels (1998) conduct two scenarios regarding CO_2 emission cost and detected that GDP losses in 2010 differed from those predicted by their scenarios. Therefore, they assert that the prospects for technical progress are incorporated and so the costs of a carbon constraint will be minimal. According to Golub et al.

(2006), costs can decline significantly through market mechanisms, such as international permit trading. Huang et al. (2008) also mention that the position of the UNFCCC Secretariat is to decouple economic growth and GHG emissions:

> The UNFCCC Secretariat has always advocated the concept that GHG emissions reduction will not affect economic growth […] in order to encourage parties to the Convention to aggressively pursue GHG reduction actions. During the COP-10 opening address that with the entry into force of the Convention 10 years ago, global energy intensity has decreased gradually, and especially that the GHG emissions growth rate is lower than the GDP grow rate (p. 245).

Moreover, the Kyoto Protocol encourages the application of the Porter Hypothesis, which suggests that a well-designed environmental policy can improve both environmental and economic performance by enhancing innovation (Esty & Porter, 2001; Golub et al., 2006; Lanoie et al., 2011; Lindmark, 2002; Manne & Richels, 1998; Porter & van der Linde, 1995). Specifically, Porter and van der Linde (1995) makes clear about the mechanism of this hypothesis:

> […] properly designed environmental standards can trigger innovation that may partially or more than fully offset the costs of complying with them. Such "innovation offsets", as we call them, can not only lower the net cost of meeting environmental regulations, but can even lead to absolute advantages over firms in

> foreign countries not subject to similar regulations. Innovation offsets will be common because reducing pollution is often coincident with improving the productivity with which resources are used. In short, firms can actually benefit from properly crafted environmental regulations that are more stringent (or are imposed earlier) than those faced by their competitors in other countries. By stimulating innovation, strict environmental regulations can actually enhance competitiveness. (p. 98)

There are some evidences from empirical literatures. For example, Manne and Richels (1998) show the possibility of the validity of the Porter Hypothesis in the Kyoto Protocol. They perform two scenarios regarding CO_2 emission cost and observed that GDP losses in 2010 differed from those predicted by their scenarios. Their results indicate that the prospects for technical progress are incorporated, and, therefore, the costs of a carbon constraint will be minimal. Concerning the relationship between emission trends and growth rate, Lindmark (2002) argues that sustained growth rates are associated with less technological and structural changes relating to CO_2 emissions in a case study of Swedish CO_2 emissions. Thus, it is suggested that time-specific technological clusters might affect EKC patterns.

Based on these studies, empirical testing is conducted to verify the economic effectiveness of the Kyoto Protocol. Drawing on the assumption that the Kyoto Protocol improves environmental performance in line with economic performance, this study posits the second hypothesis, which is, the main hypothesis of the study.

Hypothesis 2: *The effect of the Kyoto Protocol on the economic performance for Annex I Parties will not be negative.*

Table 4.1 summarizes the hypotheses of the effectiveness of the Kyoto Protocol. This study assumes the positive effect on the environment and the economy of Annex I Parties.

Table 4.1 ***Hypotheses of This Chapter***

The Effectiveness of the Kyoto Protocol	**Environment**	**Economy**
	+	+

Source: Author.

Note: + indicates a positive effect on the environments and economies of Annex I countries.

4.3 Empirical Model

4.3.1 PSM and DID Methods. This study adopts an impact evaluation technique that combines the PSM and DID methods to estimate the environmental and economic effectiveness of the Kyoto Protocol equal to the analysis of Chapter 3. However, there are specific differences in the empirical models and methods in order to improve statistical precision.

First of all, to estimate the propensity score, it is required to assume that X is the observed characteristics of research objects: $\hat{P}(X|T=1)=\hat{P}(X)$. The variables in this chapter include GDP, population, and the status of CO_2, which are considered proper variables for calculating a propensity score that reflects representative socioeconomic conditions and the status of the environment of each country, as determinants for the characteristics of participants and non-participants. In the previous chapter, only the status of pollution is applied for analyzing the economic effectiveness of LRTAP because three different pollutants are utilized for analyzing environmental performance. Since this chapter is focused on a single protocol, which is aimed at reducing CO_2 emissions, the status of CO_2 emissions is used for the both environmental and economic models.

The DID matching estimator is also used in the analysis, since it is expected to better match the participants and non-participants of the Kyoto Protocol with the data, which has participants and control observations for both before and after the program (Khandker et al., 2010). Based on the propensity score with GDP, population, and CO_2 emissions, the region of common support and balancing tests are conducted through the PSM estimation (Refer to Equation 3.3). The balancing property is satisfied and observations that fail to be included in the common support are deleted in the matching process. Consequently, only selected matched Annex I countries and control countries based on the propensity score of the baseline year are used for the DID method. The DID matching approach is implemented in two-time-periods: the adoption year and the target year of the Kyoto Protocol. Therefore, the DID estimator for the mean difference is the effectiveness of the Kyoto Protocol of participants and non-participants with the weight calculated by the PSM process. The specific equation of this statistical procedure is presented in Chapter 3.

The DID method is usually estimated in a regression framework (Khandker et al., 2010), so the variables of participation in the Kyoto Protocol indicate whether the protocol has had an effect on environmental and economic performance (Refer to Equation 3.5). To identify an appropriate model between the fixed-effect and the random-effect, a Wu–Hausman test is performed and the test results indicate that the fixed-effect model is relevant to this model. Accordingly, the fixed-effect estimation model is conducted to analyze the effectiveness of the Kyoto Protocol throughout this chapter (Refer to Equation 3.6). With the fixed-effect estimation model, the unobserved effect prior to estimation is removed, and so time invariance can be controlled (Wooldridge, 2009).

4.3.2 Two-time-period Setting. As mentioned in Chapter 3, the two-time-period setting for the base year and the target year of the Kyoto Protocol is a crucial part of the impact evaluation, combining the PSM and DID methods. To consider both with-and-without comparison and before-and-after comparison, this advanced technique requires experimental and comparison groups and two-time-period data to assume reliable counterfactual situations.

For the base year, an adoption year, an effectuation year, and a ratification year are considered because the base year is usually set as the time that nations participate in IEA

(Aakvik & Tjøtta, 2011). The history of the Kyoto Protocol is not relatively long compared to the protocols of LRTAP. Indeed, the Kyoto Protocol was adopted in 1997 and it came into force in 2005. Hence, for the empirical analysis, this study uses not only the adoption year but also the year it came in to force. Moreover, this chapter also focuses on the gap between the date of adoption and date the Kyoto Protocol came in to force. To find out the effectiveness of the protocol in more detail, this study uses in the model the date it came into force is utilized as the base year in company and the year it was adopted.

As for the target year, many previous studies have proposed that the goal year for reduction of pollutant emission is suitable for the target year of each IEA (Aakvik & Tjøtta, 2011; Helm & Sprinz, 2000). Therefore, it is reasonable to adopt the goal year for the IEA as the target year, if the IEA states a specific time period. In fact, the first official commitment of the Kyoto Protocol started in 2008 and ended in 2012, and the second commitment period has been set from January 1, 2013 to December 31, 2020. However, this study focuses on the regime participation itself and investigates the effect on the environments and economies of signatory countries before and after the protocol. Many previous studies have also estimated the effectiveness of the Kyoto Protocol on emission reduction with the data before the commitment period. In addition, quantitative data for the empirical analysis is limited for the recent years. Hence, this chapter sets the target year, 2008, as the goal year of the Annex I countries. This is applied as the target year because of it being the first impact evaluation of the Kyoto Protocol. Note that the analysis of the effectiveness of the Kyoto Protocol after 2008 will be conducted afterwards by securing sufficient data.

4.3.3 Models for Testing Hypotheses. This chapter aims to shed light on the effectiveness of the Kyoto Protocol on environment and economy by considering pollutant reduction and economic growth trends of both participants and non-participants. Therefore, this study proposes the two models to observe the effects of the Kyoto Protocol on member countries.

Both environmental and economic models contain the program effect variable—an IEA dummy—for verifying the effectiveness of the protocol. This variable is defined as being affiliated to Annex I countries, and has a value of 1 if a country *i* has joined the Kyoto Protocol in year *t* and 0 otherwise. Moreover, an Organization for Economic Cooperation and Development (OECD) dummy variable is appended to both equations to verify the Kyoto Protocol's impact on environmental performance of OECD members[22].

The environmental effectiveness model includes a GDP variable that reflects the relationship between CO_2 emissions and GDP. The model includes the logarithmic variables of CO_2 emissions and GDP variables. In addition, both dummy variables indicating the IEA

[22] The OECD aims to promote the economic growth and financial stability of member states and contribute to global economic development, contribute sound economic growth around the world, and expand world trade based on the principle of non-discriminatory and multilateral growth.

effect and OECD countries are appended for investigating the IEA effect and whether there are any differences in their effects on emission reduction among OECD countries. The environmental effectiveness model is given by the following equation:

$$Ln(\text{CO}_2\text{ emissions}) = \alpha_0 + \alpha_1\text{IEA dumm}y + \alpha_2 Ln(\text{GDP}) + \alpha_3\text{OECD dummy}$$
$$+\alpha_4\text{Time dummy} \qquad (4.1)$$

Next, the economic effectiveness model of the Kyoto Protocol is based on the Cobb–Douglas GDP function; likewise the economic model of chapter 3. Therefore, this model includes the capital, labor, and human capital variables, as components of the GDP function. All the variables are in logarithmic term, except the dummy variables. The model encompasses the IEA and OECD dummy variables within the environmental effectiveness model. Thus, this study uses the following equation to test the economic effectiveness hypothesis that posits no negative effect on the economic growth of Annex I countries:

$$Ln(\text{GDP}) = \beta_0 + \beta_1\text{IEA dummy} + \beta_2 Ln(\text{Capital}) + \beta_3 Ln(\text{Labor}) + \beta_4 Ln(\text{Human capial})$$
$$+\beta_5\text{OECD dummy} + \beta_6\text{Time dummy} \qquad (4.2)$$

Moreover, to strengthen the result of the economic effectiveness of the Kyoto Protocol, this study conducts an additional analysis of the relationship between the IEAs participation and R&D. The equation is as follows:

$$
\begin{aligned}
Ln(\text{R\&D expenditure}) = \gamma_0 + \gamma_1 \text{IEA dummy} + \gamma_2 Ln(\text{Capital}) + \gamma_3 Ln(\text{Labor}) \\
+\gamma_4 Ln(\text{Human capial}) + \gamma_5 Ln(\text{CO}_2\text{emissions}) + \gamma_6 \text{OECD dummy} \\
+\gamma_7 \text{Time dummy} \qquad (4.3)
\end{aligned}
$$

When estimating the effectiveness of the protocol, potential statistical problems appear: Traditional regression models, such as the on shown above, assume that all the independent variables are exogenous, that is, the explanatory variables that are uncorrelated with the error term (Wooldridge, 2009). However, many variables, particularly economic data, face the problem of endogeneity in multiple regression models. To overcome this statistical obstacle, instrumental variable (IV) method is one of the options.

This chapter considers this problem to draw precise results. The two models on the environmental and economic effectiveness can be described by simultaneous equations as Figure 4.2. The estimation of the environmental equation, which is included in the variables of $Ln(\text{GDP})$, has to be calculated while taking the endogenous variables problem into account.

Economic effectiveness

$$Ln(\text{GDP}) = \beta_0 + \beta_1 \text{IEA dummy} + \beta_2 Ln(\text{Capital}) + \beta_3 Ln(\text{Labor}) + \beta_4 Ln(\text{Human Capial}) + \beta_5 \text{OECD dummy} + \beta_6 \text{Time dummy}$$

Environmental effectiveness

$$Ln(\text{CO}_2 \text{ emissions}) = \alpha_0 + \alpha_1 \text{IEA dumm}y + \alpha_2 Ln(\text{GDP}) + \alpha_3 \text{OECD dummy} + \alpha_4 \text{Time dummy}$$

Figure 4.2 **Simultaneous Equations between Economic and Environmental Effectiveness**

Source: Author.

The endogeneity of $Ln(\text{GDP})$ can be verified with an augmented regression test (Durbin–Wu–Hausman test). The equation for testing the endogeneity of $Ln(\text{GDP})$ can easily be formed by including the residuals of $Ln(\text{GDP})$ in a regression of the original model (Davidson & MacKinnon, 1993). The results indicate that OLS is not consistent because the coefficient of the residuals of $Ln(\text{GDP})$ is significantly different from zero with the small p-value (<1%). As a result, this chapter applies a Two Stage Least Squares (2SLS) approach by applying the IV method to estimate the environmental effectiveness model. Wooldridge (2009) describes a 2SLS approach as "an instrumental variables estimator where the IV for an endogenous explanatory variable is obtained as the fitted value from regressing the endogenous explanatory variable on all exogenous variables" (p. 847).

The basic process of 2SLS estimator is consists of three steps: First, because the dependent variable $Ln(\text{GDP})$ of the economic equation model is an endogenous explanatory variable of the environmental effectiveness model, the within estimator is calculated from IVs, such as $Ln(\text{Capital})$, $Ln(\text{Labor})$, $Ln(\text{Human Capial})$, and the exogenous explanatory variables. Second, a fitted value of $Ln(\text{GDP})$ is estimated from the estimator calculated by the previous step; $Ln\widehat{(\text{GDP}})$ presents the fitted value of $Ln(\text{GDP})$. Third, the adjusted regression model containing $Ln\widehat{(\text{GDP}})$ instead of the endogenous explanatory variable $Ln(\text{GDP})$ is established for investigating the within estimator of the environmental effectiveness of the Kyoto Protocol. Accordingly, the following equation of environmental effectiveness is estimated to gain the fitted value of the 2SLS fixed-effect estimator:

$$Ln(\text{CO}_2\text{ emissions}) = \delta_0 + \delta_1\text{IEA dumm}y + \delta_2\, Ln\widehat{(\text{GDP}}) + \delta_3\text{OECD dummy} + \delta_4\text{Time dummy} \quad (4.4)$$

In addition, the order condition for estimating IVs is that the number of exogenous explanatory variables should be greater than the number of endogenous explanatory variables. The analysis of this chapter satisfies this condition, since there is one endogenous explanatory variable and three exogenous explanatory variables in the equation. Another important point is that time-invariant variables, such as a dummy variable, cannot be used as IV. This is because time-invariant variables are omitted in the process of within transformation. All empirical models are estimated using STATA/SE 11.2 for Windows (32-bit).

4.4 Data Description

To examine the environmental and economic effectiveness of the Kyoto Protocol, this study uses a country-level panel data set of 209 countries for the period from 1997–2008. Through the process of the PSM method, this study uses only the matched samples of the base year and target year in the regression analysis. Therefore, some countries, which are succeeding in the matching process, are used in the final estimations.

The empirical models contain two binary indicators: First, the program effect variables of the models determine whether the parties belong to Annex I or not. This indicator is given a value of 1 if the country is included Annex I. The information regarding the Kyoto Protocol participation by each country in the base year and target year is adopted from UNFCCC (n.d.), which is the secretariat of the Kyoto Protocol. Second, the OECD dummy is another variable that is given a value of 1 if a nation is a member of the OECD countries[23]. Third, the time dummy is given a value of 1 if the sample is in the target year.

As shown in Table 4.2, all the remaining variables are collected from WDI (World Bank, n.d.). To estimate the environmental effectiveness equation, the country-level emission data of CO_2 and GDP of each country is collected. Even though CO_2 emissions (KT) are available from various sources, only the most reliable WDI data is used.

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[23] Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israël, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States (Organisation for Economic Co-operation and Development (OECD, n.d.).

Table 4.2 ***Sources of Data***

Variables	Sources
Status of participating in IEAs	UNFCCC (n.d.).
CO_2 emissions (KT)	WDI (World Bank, n.d.)
Social factors (GDP, Population)	
GDP function (Capital, Labor, Human capital)	
Gross domestic expenditure on R&D	

Source: Author.

This study uses the data set that contain as many countries as possible for the GDP function of the economic effectiveness equation. Consequently, gross fixed capital formation, total labor force participation rate, (parentage of total population ages from 15 to 64), and adjusted savings-education expenditure (current US dollars) are used as the capital, labor, and human capital variables, respectively. Owing to data limitations, GDP and gross fixed capital formation are in constant US dollars from the year 2000, while adjusted savings-education expenditure is in current US dollars. For the analysis of R&D, gross domestic expenditure on R&D is used.

Table 4.3 and 4.4 show the descriptive statistics of each variable in both the 1997 and 2005 base year models after the matching process.

Table 4.3 ***Descriptive Statistics of Full Sample: 1997 Base Year Model***

Variables	N	Mean	SD	Min	Max
IEA dummy	171	0.222	0.417	0	1
***Ln*(CO$_2$ emissions)**	171	10.778	1.980	5.905	15.761
***Ln*(Capital)**	171	23.353	1.968	18.516	28.373
***Ln*(Labor)**	171	4.201	0.138	3.766	4.450
***Ln*(Human capital)**	171	21.961	2.026	17.183	27.260
***Ln*(GDP)**	171	24.847	1.946	20.050	30.116
OECD dummy	171	0.345	0.477	0	1
Time dummy	171	0.444	0.498	0	1
R&D	73	8.012	1.813	3.992	12.498

Source: Author.

Table 4.4 ***Descriptive Statistics of Full Sample: 2005 Base Year Model***

Variables	N	Mean	SD	Min	Max
IEA dummy	169	0.231	0.423	0	1
***Ln*(CO$_2$ emissions)**	169	10.923	1.915	5.982	15.761
***Ln*(Capital)**	169	23.631	1.826	19.063	28.419
***Ln*(Labor)**	169	4.215	0.137	3.752	4.483
***Ln*(Human capital)**	169	22.305	1.912	17.687	27.260
***Ln*(GDP)**	169	25.097	1.831	20.819	30.116
OECD dummy	169	0.355	0.480	0	1
Time dummy	169	0.462	0.500	0	1
R&D	76	8.166	1.807	4.537	12.498

Source: Author.

4. 5 Results

Table 4.5 reports the results of the fixed-effect regressions combining the PSM and DID methods that reflects the environmental and economic effectiveness of the Kyoto Protocol.

Table 4.5 ***Empirical Results on the Effectiveness of the Kyoto Protocol***

Model	**Environmental effectiveness**		**Economic effectiveness**	
Object variable	*Ln*(CO_2 emissions)		*Ln*(GDP)	
Base year	1997	2005	1997	2005
Target year	2008	2008	2008	2008
IEA dummy	-0.246***	-0.097***	-0.097***	-0.029**
	(0.054)	(0.037)	(0.024)	(0.014)
***Ln*(Capital)**	-	-	0.286***	0.137**
			(0.054)	(0.059)
***Ln*(Labor)**	-	-	-0.298	-0.210
			(0.278)	(0.235)
***Ln*(Human capital)**	-	-	0.079*	0.126***
			(0.046)	(0.032)
$\boldsymbol{Ln}(\widehat{\mathbf{GDP}})$	0.360*	0.195	-	-
	(0.205)	(0.374)		
OECD dummy	-0.192	-	0.201***	-
	(0.240)		(0.019)	
Time dummy	0.135	0.076	0.260***	0.075***
	(0.097)	(0.066)	(0.034)	(0.018)
Constants	1.882	6.013	17.512***	19.911***
	(5.043)	(9.384)	(1.569)	(1.291)
$\mathbf{R^2}$	0.825	0.807	0.955	0.966
Number of sample	171	169	171	169
Number of groups	89	86	89	86

Source: Author.

*Note: ***, **, and * show 1%, 5%, and 10% significance, respectively.*

Since only the matched samples are included in the regression models, 171 or 169 samples (about two-time pairs of 84 or 86 nations) were finally used for our analysis. The effect of the Kyoto Protocol on the environment and economies of Annex I Parties is presented with the coefficients of the IEA variables.

Note that the OECD dummy are dropped in the base year 2005 regressions of both the environmental and the economic effectiveness analyses because all parties belonging to Annex I have also been OECD members since 2005. In addition, all the variables (excluding the dummy variables) are used as natural log values.

4.5.1 Environmental Effectiveness. The first and second columns of Table 4.5 report the results of the environmental effectiveness of the Kyoto Protocol from 1997 to 2005 and from 2005 to 2008, respectively. Overall, the first model fits the data reasonably well. Although R^2 of the 2005 base year model is almost at the same level, the coefficient of GDP is also statistically significant in the 1997 base year model. R^2 is 0.825 for the 1997 base year model and 0.807 for the 2005 base year model, which indicates that more than 80% of the variations in CO_2 emissions can be explained by both the models.

First, the IEA dummy variables, (i.e. the program effect variable), indicates the effectiveness of the Kyoto Protocol on emission reduction. The coefficients of the IEA dummy are statistically significant at the 1% level with a negative sign in both the columns.

These results show that belonging to the group of Annex I countries has a significant effect on the reduction of CO_2 emissions. Specifically, Annex I countries are approximately 25% more effective in reducing CO_2 emissions than non-participating countries in the 1997 base year model, and approximately 10% more effective in the 2005 base year model. These highly significant results suggest the evidence to support Hypothesis 1, which assumes that participating in Annex I of the Kyoto Protocol has a positive effect on reducing CO_2 emissions.

The above results are consistent with the discussions concerning the real influence of the Kyoto Protocol. For instance, Grunewald and Martínez-Zarzoso (2009, 2011) indicate that the obligations of the Kyoto Protocol have a reducing effect on CO_2 emissions. UNFCCC (2012), which maintains that significant GHG emission reductions are observed among Annex I countries, also corresponds with the statistically significant results of this chapter. Moreover, these results support the previous studies about other pollutants that argue that there is a positive effect of participating in IEAs for pollution reduction (Helm & Sprinz, 2000; Kim et al., 2012; Murdoch et al., 1997). They realize that engaging in international environmental governance is an effective way to prevent the discharge of pollution. Since this study uses advanced method, which can control both pre- and post-program group differences, the effectiveness of the Kyoto Protocol has become clearer, and therefore, it complements the limitations of previous studies, such as when they failed to grasp the effect of IEAs while controlling for the external factors of each nation.

Second, the signs of the coefficients of the GDP variables, which are used as IVs for the economic effectiveness model for solving the problem of endogenous variables, are positive in both the models. From this result, it is revealed that CO_2 emissions increase with economic development. However, only the GDP variable of the analysis of the base year 1997 is statistically significant at the 10% level, whereas it seems hard to derive a statistically significant result from the linear relationship between economic growth and CO_2 emissions in the second model. Although the research period of the second model covers only four years, this contradicts the early findings by Kumazawa and Callaghan (2012) and Huang et al. (2008) that the levels of CO_2 emissions are highly affected by the level of economic activity. Such insignificance may be due to the stage of economic growth of some of the developing countries, which implies that they are still experiencing the negative influences of economic development during the period of the second model, thus exceeding the impact of the IEAs.

This result supports the argument that CO_2 emissions and economic growth have a positive relationship. From the empirical result of the first model, it is implies that a 1% increase in GDP triggers more CO_2 emissions by about 36%. Some previous studies have tried to determine whether EKC is an adoptable universal theory in CO_2 emissions, and explain that CO_2 emissions tend to increase in line with economic development, because CO_2 emissions are closely related to fossil fuel usage and industrial development. Moreover, de

Bruyn et al. (1998) investigate the relationship and economic growth with CO_2, NO_X, and SO_2 emissions in the Netherlands, the UK, the USA, and Western Germany, and argue that emissions correlate positively with economic growth, but the structural and technological changes might help reduce emissions. Talukdar and Meisner (2001) also find the evidence supporting the monotonic relationship between CO_2 emissions and economic growth that decreasing beyond a particular turning point is not identified in their analysis. To sum up, empirical evidences from other studies support a monotonic relationship between GDP and CO_2 emissions, even though the existence of an EKC for CO_2 is still disputed (Lantz & Feng, 2006).

Finally, the OECD and time dummies have an insignificant impact on CO_2 emissions in both the base year models. That is, there are no statistically significant differences in CO_2 emission reduction among OECD countries from before to after the Kyoto Protocol.

4.5.2 Economic Effectiveness. The third and last columns of Table 4.5 provide the results on the economic effectiveness of the Kyoto Protocol. First, the IEA dummy is highly significant at more than 5% significance level with negative signs. This result demonstrates that being one of the Annex I countries has a negative effect on economic performance. This is similar to the result from the GDP variables of the environmental effectiveness analysis. The economic performance of Annex I countries deteriorates by approximately 10% from

1997 to 2008 and 3% from 2005 to 2008. From this result, it is found that Annex I counties, on which reduction obligations are imposed, show lower economic growth than other counties. Consequently, Hypothesis 2 that assumes no negative economic effects from an IEA is rejected.

These findings coincide with the outcomes of the empirical analyses by Nordhaus and Boyer (1999) and Böhringer et al. (2001). Although most Annex I countries are developed countries and the analysis period is prior to the beginning of the first official commitment period, curtailment of economic growth may appear due to expected socioeconomic costs, investments, and corresponding policies for emission reduction that can be a burden to the Annex I countries. As a result, the economic burden is placed completely on Annex I countries, and their economic outputs are reduced due to the need for energy reduction, which increases production costs (Nordhaus & Boyer, 1999).

This chapter assumes that participating in Annex I does not offset economic performance, since the applicability of the Porter Hypothesis built on the flexible market-based mechanisms is highly acclaimed. Moreover, some scholars point out that the possibility of international spillover effects where industrialized countries will tend to shift part of their domestic adjustment costs to trading partners in the developing countries by demanding fewer exports (Böhringer et al., 2001). However, the empirical result of the economic effectiveness of the Kyoto Protocol shows that Annex I countries cannot avoid the economic burden of compliance costs in the analysis period.

Contrary to expectations, the result of this chapter the Porter Hypothesis does not seem to be a valid model for determining the economic effectiveness of the Kyoto Protocol. Two pieces of theoretical evidence can be considered the reasons for this result. First, the institutional factors including the enforcement, sanction, or implementation procedures of the Kyoto Protocol influence the effectiveness of the protocol. For example, legalization and flexibility mechanisms of IEA can either worsen or improve its effectiveness (Böhmelt & Pilster, 2010). More specifically, legal binding force may have a beneficial effect on the effectiveness whereas flexible mechanisms provide capacity to rapidly adjust to new circumstances in the implementation process (Böhmelt & Pilster, 2010; Hafner-Burton & Tsutsui, 2005; Kucik & Reinhardt, 2008).

Second, the CDM mechanism, which is prescribed in Article 12 of the protocol, can be another reason. The objectives of the CDM are demonstrated in Article as follows:

> 3. Under the clean development mechanism:
>
> (a) Parties not included in Annex I will benefit from project activities resulting in certified emission reductions; and
>
> (b) Parties included in Annex I may use the certified emission reductions accruing from such project activities to contribute to compliance with part of their quantified emission limitation and reduction commitments under Article 3, as determined by

the Conference of the Parties serving as the meeting of the Parties to this Protocol. (Article 12)

With this mechanism, Annex I Parties are allowed to meet part of their emission reduction commitments under the Kyoto Protocol by buying Certified Emission Reductions (CER) of CDM emission reduction projects in developing countries (Carbon Trust, 2009). If Annex I Parties participate in CDM projects to implement project-based emission reductions in developing countries, their need for research and development of technology or systems for emission reductions shrinks, since comparatively lower technology is still efficacious in lowering countries' emissions. Therefore, with the CDM mechanism, it is difficult to present evidence to support the Porter Hypothesis that assumes that well-made environmental regulations encourage innovation and eventually achieve cost savings. Thus, the effort of Annex I Parties to reduce emissions in developing countries is hard to induce cost cutting in one's own country.

To support these arguments, an additional analysis of the relationship between Annex I participation and gross domestic expenditure on R&D was conducted. The result is presented in Table 4.6.

Table 4.6 *Empirical Results on Participating in IEA and R&D*

Model	**Gross domestic expenditure on R&D**	
Object variable	*Ln*(R&D expenditure)	
Base year	1997	2005
Target year	2008	2008
IEA dummy	-0.551**	-0. 010
	(0.239)	(0.120)
***Ln*(Capital)**	-0.148	0.146
	(0. 533)	(0.390)
***Ln*(Labor)**	-3.385	-3.892
	(2.260)	(2.377)
***Ln*(Human capital)**	0.133	-0.275
	(0.329)	(0.299)
***Ln*(CO_2)**	1.993***	-0.795*
	(0.460)	(0.445)
OECD dummy	0.901***	-
	(0. 179)	
Time dummy	0.615*	0.150
	(0.334)	(0.132)
Constants	-1.614	36.977***
	(16.312)	(11.101)
R^2	0.586	0.756
Number of sample	73	76
Number of group	40	40

Source: Author.

*Note: ***, **, and * show 1%, 5%, and 10% significance, respectively.*

As respected, the resultant IEA dummy variable indicates that participating Annex I countries do not have an increased gross domestic expenditure on R&D, rather a negative effect is observed in the 1997 base year model. Interestingly, the coefficients of the CO_2 variables have opposite signs in each model. This result demonstrates that increasing CO_2

emissions promotes national investments on R&D in the long term, while negative effects are expected in the short term. In addition, the OECD dummy is also highly significant at the 1% level; this result is in the line with the previous result of the economic effectiveness model that shows a positive coefficient of the OECD variables. The positive effect of the OECD dummy on the expenditure on R&D indicates that OECD countries invest in R&D 90% more than other countries.

Note that the analysis period may not be satisfactory to examine the economic effectiveness of the Kyoto Protocol, since the practical effects of international environmental policies take a long time to manifest. While the environmental effectiveness of the Kyoto Protocol have been identified in the previous analysis, more long-term follow-up studies are needed to show that international environmental policies have positive effects for both environmental and economic performance.

Return to the main analysis, the control variables of the elements of production functions, such as capital, labor and human capital, indicate that while the coefficients of the capital and human capital variables show positive signs and are statistically robust, the labor variables are negative and the estimated coefficients are not statistically robust. The capital variables are statistically significant at the 1% level and about 29% of GDP growth is observed per 1% of capital increase in the 1997 base year model. The 2005 base year model shows a 14% improvement in GDP per 1% of capital growth. Furthermore, the human capital variable is also statistically significant and has an approximately 8% and 13% positive effect on GDP in each model. In contrast, labor has no statistically significant effect on the economic growth in this analysis. These results indicate that capital investment and human capital act as national economic locomotives.

Finally, according to the first model, the OECD dummy variable has a highly significant effect on GDP. The economic performance of OECD member nations is approximately 20% higher than that of other countries. This suggests that the economic level of OECD countries is relatively better than other countries. The coefficients of the time dummy show positive signs in both the models, much like the analysis of the environmental effectiveness, but highly significant at the 1% level. Hence, this study infers that the introduction of the Kyoto Protocol has had a significant impact upon economic performance.

4.5.3 Prediction of the Effectiveness among Annex I Parties. The step that follows the fixed-effect regression procedure with the impact evaluation combining the PSM and DID methods is the estimation of the environmental and economic effectiveness of the Kyoto Protocol, based on the result of both the base year models. This prediction value is calculated among Annex I countries. Table 4.7 reports the predicted estimations of the real and hypothetical IEA effect on CO_2 emissions and GDP growth for both the base years.

Table 4.7 ***Prediction of the Effectiveness of the Kyoto Protocol***

	Model	Participate (Real)	Non-participate (Hypothetic)	(Hypothetic)-(Real) (%)
CO_2	1997	8,790	11,242	2,452
(Emissions (MT))				(27.890%)
	2005	12,844	14,153	1,308
				(10.186%)
GDP	1997	27,419	30,212	2,793
(Constant 2000				(10.186%)
Billion US dollars)	2005	27,725	28,540	816
				(2.942%)

Source: Author.

Note: The actual measurement values of CO2are 114,263MT in 2008 and 14,511MT in 2007. The actual measurement values of GDP are 23,064 billion US dollars in 2008 and 29,952 billion US dollars in 2007.

In this prediction, the real and hypothetic values are compared to examine the expected differences. The real situation of CO_2 emissions and GDP are regarded as the estimated values when nations participate in Annex I. Therefore, this estimated value of 2008 is calculated based on the real data of the base year, applying the IEA dummy variable 1. On the contrary, the hypothetical situation is an assumption if nations had not participated in Annex I. Thus, the IEA dummy variable is shifted to 0 for presuming a counterfactual situation, and then the hypothetical value is estimated as above.

In the case of environmental effectiveness, participating in Annex I produced a positive effect on the CO_2 emissions. The gap between the real and hypothetical estimation is 2,452 MT in the 1997 base year model and 1,308 MT in the 2005 base year model. This implies that if countries were not required to reduce CO_2 emissions, Annex I countries would have emitted more CO_2—about 28% based on the first model and 10% for the second model.

On the contrary, in the case of economic effectiveness, as discussed in the result section, participating in Annex I has had a negative effect on GDP growth. More specifically, 2,793 billion US dollars—approximately 10% GDP growth— is observed in the hypothetical situation of the 2005 base year model, whereas 816 billion US dollars—3% GDP growth—is estimated in the 2005 base year model. These large gaps indicate considerable economic impact on IEA participants.

Note that although this prediction is accomplished with the fixed-effect regression equations that are estimated precisely, it is inevitable that there will be some gaps between the actual measurement value of 2008 and the predicted value due to unexpected socioeconomic changes. In particular, since the target year of this study is 2008, which was when the impact of the subprime mortgage crisis occurred, it is difficult to reflect a rapid decrease of GDP.

These numerical results contribute to our understanding of the actual amounts of emission reduction and economic burden caused by the Kyoto Protocol. Overall, the prediction results demonstrate that even though the effect of the Kyoto Protocol on Annex I countries offsets economic growth, its emission reduction effect is much greater than the hindrance effect to economic growth. However, regarding the possibility of reducing costs, the Kyoto Protocol has not managed to improve both in terms of environmental and economic performance.

4.6 Chapter Conclusions

Along with the increasing number of IEAs, analyzing the effectiveness of IEAs has recently become of interest to scholars. Despite this increasing academic interest, quantitative studies on the effectiveness of IEAs are still limited and often controversial. Research on the effectiveness of IEAs has largely focused on environmental performance and only few studies have tested the economic effectiveness of IEAs.

This chapter attempted to examine the competing claims about the effectiveness of the Kyoto Protocol using country-level panel data of 209 countries for the period 1997–2008. This study estimates the effectiveness combining the PSM and DID methods to take advantage of the panel nature of our data to control for time and location. To provide a better understanding, this study uses the two models by setting different base years. Moreover, this study formulates two hypotheses to estimate the effectiveness. The first aspect focused on the environmental effectiveness, which perceived the effect of the protocol in terms of reducing CO_2 emissions. The other aspect focused on estimating the IEA effect on economic improvement.

This study found that only the first hypothesis that assumed that the Kyoto Protocol had a significant effect on reducing emissions have a robust empirical support. This result confirmed effective CO_2 emission reductions among Annex I Parties for the both the base year models at a highly significant level. The second hypothesis that assumed that the IEA had no negative effect on GDP was rejected, implying that even though the Kyoto Protocol included the establishment of market-based mechanisms for reducing costs, it is currently difficult to improve both environmental and economic performance. The institutional factors of IEAs and the slippage effect through the CDM mechanism are suggested with theoretical evidence. The result of the additional analysis between Annex I participation and expenditure on R&D supports this argument.

This study opens avenues for further research in analyzing other IEAs from a long-term perspective. Although the empirical results are robust and provide evidence about the effectiveness of IEAs, the research objective is limited to the Kyoto Protocol and the analysis periods are not sufficiently complete. Therefore, the possibility exists for generating a more interesting result if the analysis is conducted with longer periods, including the first commitment period. Further research could use broader data on various IEAs to estimate and provide a more generalized and detailed result on whether IEAs improve environmental performance in line with economic performance. Finally, the synergistic effect between environmental policies and economic performance can be evaluated in the field of IEAs.

The next chapter intends to solve the final parts of the research questions; namely *which regime elements of IEAs have a beneficial effect on the environmental and economic* *performance of member countries?* The empirical results of Chapter 3 and Chapter 4 light on a clue that other factors than IEA participation, such as the institutional characteristics of IEAs, exert influence upon the environmental and economic effectiveness of IEAs. Chapter 5 determines how regime elements affect a positive effect on both the environmental and the economic effectiveness of IEAs using the database containing various IEAs.

Appendix 4.1 Status of Participants of the Kyoto Protocol

Participant	Signature	Ratification Acceptance (A) Accession (a) Approval (AA)	Entry into force
Afghanistan		25 Mar 2013 a	23 June 2013
Albania		1 Apr 2005 a	30 Jun 2005
Algeria		16 Feb 2005 a	17 May 2005
Angola		8 May 2007 a	6 Aug 2007
Antigua and Barbuda	16 Mar 1998	3 Nov 1998	16 Feb 2005
Argentina	16 Mar 1998	28 Sep 2001	16 Feb 2005
Armenia		25 Apr 2003 a	16 Feb 2005
Australia*	29 Apr 1998	12 Dec 2007	11 Mar 2008
Austria*	29 Apr 1998	31 May 2002	16 Feb 2005
Azerbaijan		28 Sep 2000 a	16 Feb 2005
Bahamas		9 Apr 1999 a	16 Feb 2005
Bahrain		31 Jan 2006 a	1 May 2006
Bangladesh		22 Oct 2001 a	16 Feb 2005
Barbados		7 Aug 2000 a	16 Feb 2005
Belarus*		26 Aug 2005 a	24 Nov 2005
Belgium*	29 Apr 1998	31 May 2002	16 Feb 2005
Belize		26 Sep 2003 a	16 Feb 2005
Benin		25 Feb 2002 a	16 Feb 2005
Bhutan		26 Aug 2002 a	16 Feb 2005
Bolivia	9 Jul 1998	30 Nov 1999	16 Feb 2005
Bosnia and Herzegovina		16 Apr 2007 a	15 Jul 2007
Botswana		8 Aug 2003 a	16 Feb 2005
Brazil	29 Apr 1998	23 Aug 2002	16 Feb 2005
Brunei Darussalam		20 Aug 2009 a	18 Nov 2009
Bulgaria*	18 Sep 1998	15 Aug 2002	16 Feb 2005
Burkina Faso		31 Mar 2005 a	29 Jun 2005
Burundi		18 Oct 2001 a	16 Feb 2005
Cabo Verde		10 Feb 2006 a	11 May 2006
Cambodia		22 Aug 2002 a	16 Feb 2005
Cameroon		28 Aug 2002 a	16 Feb 2005
Canada*	[29 Apr 1998]	[17 Dec 2002]	16 Feb 2005

			[15 Dec 2012 w]
Central African Republic		18 Mar 2008 a	16 Jun 2008
Chad		18 Aug 2009 a	17 Nov 2009
Chile	17 Jun 1998	26 Aug 2002	16 Feb 2005
China	29 May 1998	30 Aug 2002 AA [2]	16 Feb 2005
Colombia		30 Nov 2001 a	16 Feb 2005
Comoros		10 Apr 2008 a	9 Jul 2008
Congo		12 Feb 2007 a	13 May 2007
Cook Islands	16 Sep 1998	27 Aug 2001	16 Feb 2005
Costa Rica	27 Apr 1998	9 Aug 2002	16 Feb 2005
Cote d'Ivoire		23 Apr 2007 a	22 Jul 2007
Croatia*	11 Mar 1999	30 May 2007	28 Aug 2007
Cuba	15 Mar 1999	30 Apr 2002	16 Feb 2005
Cyprus		16 Jul 1999 a	16 Feb 2005
Czech Republic*	23 Nov 1998	15 Nov 2001 AA	16 Feb 2005
Democratic People's Republic of Korea		27 Apr 2005 a	26 Jul 2005
Democratic Republic of Congo		23 Mar 2005 a	21 Jun 2005
Denmark*	29 Apr 1998	31 May 2002 [3]	16 Feb 2005
Djibouti		12 Mar 2002 a	16 Feb 2005
Dominica		25 Jan 2005 a	25 Apr 2005
Dominican Republic		12 Feb 2002 a	16 Feb 2005
Ecuador	15 Jan 1999	13 Jan 2000	16 Feb 2005
Egypt	15 Mar 1999	12 Jan 2005	12 Apr 2005
El Salvador	8 Jun 1998	30 Nov 1998	16 Feb 2005
Equatorial Guinea		16 Aug 2000 a	16 Feb 2005
Eritrea		28 Jul 2005 a	26 Oct 2005
Estonia*	3 Dec 1998	14 Oct 2002	16 Feb 2005
Ethiopia		14 Apr 2005 a	13 Jul 2005
European Union*	29 Apr 1998	31 May 2002 AA	16 Feb 2005
Fiji	17 Sep 1998	17 Sep 1998	16 Feb 2005
Finland*	29 Apr 1998	31 May 2002	16 Feb 2005
France*	29 Apr 1998	31 May 2002 AA	16 Feb 2005
Gabon		12 Dec 2006 a	12 Mar 2007
Gambia		1 Jun 2001 a	16 Feb 2005
Georgia		16 Jun 1999 a	16 Feb 2005
Germany*	29 Apr 1998	31 May 2002	16 Feb 2005

Ghana		30 May 2003 a	16 Feb 2005
Greece*	29 Apr 1998	31 May 2002	16 Feb 2005
Grenada		6 Aug 2002 a	16 Feb 2005
Guatemala	10 Jul 1998	5 Oct 1999	16 Feb 2005
Guinea		7 Sep 2000 a	16 Feb 2005
Guinea-Bissau		18 Nov 2005 a	16 Feb 2005
Guyana		5 Aug 2003 a	16 Feb 2005
Haiti		6 Jul 2005 a	4 Oct 2005
Honduras	25 Feb 1999	19 Jul 2000	16 Feb 2005
Hungary*		21 Aug 2002 a	16 Feb 2005
Iceland*		23 May 2002 a	16 Feb 2005
India		26 Aug 2002 a	16 Feb 2005
Indonesia	13 Jul 1998	3 Dec 2004	3 Mar 2005
Iran (Islamic Republic of)		22 Aug 2005 a	20 Dec 2005
Iraq		28 Jul 2009 a	26 Oct 2009
Ireland*	29 Apr 1998	31 May 2002	16 Feb 2005
Israel	16 Dec 1998	15 Mar 2004	16 Feb 2005
Italy*	29 Apr 1998	31 May 2002	16 Feb 2005
Jamaica		28 Jun 1999 a	16 Feb 2005
Japan*	28 Apr 1998	4 Jun 2002 A	16 Feb 2005
Jordan		17 Jan 2003 a	16 Feb 2005
Kazakhstan**	12 Mar 1999	19 Jun 2009	17 Sep 2009
Kenya		25 Feb 2005 a	26 May 2005
Kiribati		7 Sep 2000 a	16 Feb 2005
Kuwait		11 Mar 2005 a	9 Jun 2005
Kyrgyzstan		13 May 2003 a	16 Feb 2005
Lao People's Democratic Republic		6 Feb 2003 a	16 Feb 2005
Latvia*	14 Dec 1998	5 Jul 2002	16 Feb 2005
Lebanon		13 Nov 2006 a	11 Feb 2007
Lesotho		6 Sep 2000 a	16 Feb 2005
Liberia		5 Nov 2002 a	16 Feb 2005
Libya		24 Aug 2006 a	22 Nov 2006
Liechtenstein*	29 Jun 1998	3 Dec 2004	3 Mar 2005
Lithuania*	21 Sep 1998	3 Jan 2003	16 Feb 2005
Luxembourg*	29 Apr 1998	31 May 2002	16 Feb 2005
Madagascar		24 Sep 2003 a	16 Feb 2005
Malawi		26 Oct 2001 a	16 Feb 2005

Malaysia	12 Mar 1999	4 Sep 2002	16 Feb 2005
Maldives	16 Mar 1998	30 Dec 1998	16 Feb 2005
Mali	27 Jan 1999	28 Mar 2002	16 Feb 2005
Malta*	17 Apr 1998	11 Nov 2001	16 Feb 2005
Marshall Islands	17 Mar 1998	11 Aug 2003	16 Feb 2005
Mauritania		22 Jul 2005 a	20 Oct 2005
Mauritius		9 May 2001 a	16 Feb 2005
Mexico	9 Jun 1998	7 Sep 2000	16 Feb 2005
Micronesia (Federated states of)	17 Mar 1998	21 Jun 1999	16 Feb 2005
Monaco*	29 Apr 1998	27 Feb 2006	28 May 2006
Mongolia		15 Dec 1999 a	16 Feb 2005
Montenegro		4 Jun 2007 a	2 Sep 2007
Morocco		25 Jan 2002 a	16 Feb 2005
Mozambique		18 Jan 2005 a	18 Apr 2005
Myanmar		13 Aug 2003 a	16 Feb 2005
Namibia		4 Sep 2003 a	16 Feb 2005
Nauru		16 Aug 2001 a	16 Feb 2005
Nepal		16 Sep 2005 a	15 Dec 2005
Netherlands*	29 Apr 1998	31 May 2002 A [4]	16 Feb 2005
New Zealand*	22 May 1998	19 Dec 2002 [5]	16 Feb 2005
Nicaragua	7 Jul 1998	18 Nov 1999	16 Feb 2005
Niger	23 Oct 1998	30 Sep 2004	16 Feb 2005
Nigeria		10 Dec 2004 a	10 Mar 2005
Niue	8 Dec 1998	6 May 1999	16 Feb 2005
Norway*	29 Apr 1998	30 May 2002	16 Feb 2005
Oman		19 Jan 2005 a	19 Apr 2005
Pakistan		11 Jan 2005 a	11 Apr 2005
Palau		10 Dec 1999 a	16 Feb 2005
Panama	8 Jun 1998	5 Mar 1999	16 Feb 2005
Papua New Guinea	2 Mar 1999	28 Mar 2002	16 Feb 2005
Paraguay	25 Aug 1998	27 Aug 1999	16 Feb 2005
Peru	13 Nov 1998	12 Sep 2002	16 Feb 2005
Philippines	15 Apr 1998	20 Nov 2003	16 Feb 2005
Poland*	15 Jul 1998	13 Dec 2002	16 Feb 2005
Portugal*	29 Apr 1998	31 May 2002 AA	16 Feb 2005
Qatar		11 Jan 2005 a	11 Apr 2005

Republic of Korea	25 Sep 1998	8 Nov 2002	16 Feb 2005
Republic of Moldova		22 Apr 2003 a	16 Feb 2005
Romania*	5 Jan 1999	19 Mar 2001	16 Feb 2005
Russian Federation*	11 Mar 1999	18 Nov 2004	16 Feb 2005
Rwanda		22 Jul 2004 a	16 Feb 2005
Saint Kitts and Nevis		8 Apr 2008 a	7 Jul 2008
Saint Lucia	16 Mar 1998	20 Aug 2003	16 Feb 2005
Saint Vincent and the Grenadines	19 Mar 1998	31 Dec 2004	31 Mar 2005
Samoa	16 Mar 1998	27 Nov 2000	16 Feb 2005
San Marino		28 April 2010	27 Jul 2010
Sao Tome and Principe		25 Apr 2008 a	24 Jul 2008
Saudi Arabia		31 Jan 2005 a	1 May 2005
Senegal		20 Jul 2001 a	16 Feb 2005
Serbia		19 Oct 2007 a	17 Jan 2008
Seychelles	20 Mar 1998	22 Jul 2002	16 Feb 2005
Sierra Leone		10 Nov 2006 a	8 Feb 2007
Singapore		12 Apr 2006 a	11 Jul 2006
Slovakia*	26 Feb 1999	31 May 2002	16 Feb 2005
Slovenia*	21 Oct 1998	2 Aug 2002	16 Feb 2005
Solomon Islands	29 Sep 1998	13 Mar 2003	16 Feb 2005
Somalia		26 July 2010	24 Oct 2010
South Africa		31 Jul 2002 a	16 Feb 2005
Spain*	29 Apr 1998	31 May 2002	16 Feb 2005
Sri Lanka		3 Sep 2002 a	16 Feb 2005
Sudan		2 Nov 2004 a	16 Feb 2005
Suriname		25 Sep 2006 a	24 Dec 2006
Swaziland		13 Jan 2006 a	13 Apr 2006
Sweden*	29 Apr 1998	31 May 2002	16 Feb 2005
Switzerland*	16 Mar 1998	9 Jul 2003	16 Feb 2005
Syrian Arab Republic		27 Jan 2006 a	27 Apr 2006
Tajikistan		29 Dec 2008 a	29 Mar 2009
Thailand	2 Feb 1999	28 Aug 2002	16 Feb 2005
The Former Yugoslav Republic of Macedonia		18 Nov 2004 a	16 Feb 2005
Timor-Leste		14 Oct 2008 a	12 Jan 2009
Togo		2 Jul 2004 a	16 Feb 2005
Tonga		14 Jan 2008 a	13 Apr 2008

Trinidad and Tobago	7 Jan 1999	28 Jan 1999	16 Feb 2005
Tunisia		22 Jan 2003 a	16 Feb 2005
Turkey*		28 May 2009 a	26 Aug 2009
Turkmenistan	28 Sep 1998	11 Jan 1999	16 Feb 2005
Tuvalu	16 Nov 1998	16 Nov 1998	16 Feb 2005
Uganda		25 Mar 2002 a	16 Feb 2005
Ukraine*	15 Mar 1999	12 Apr 2004	16 Feb 2005
United Arab Emirates		26 Jan 2005 a	26 Apr 2005
United Kingdom of Great Britain and Northern Ireland*	29 Apr 1998	31 May 2002 [6,7]	16 Feb 2005
United Republic of Tanzania		26 Aug 2002 a	16 Feb 2005
United States of America*	12 Nov 1998		
Uruguay	29 Jul 1998	5 Feb 2001	16 Feb 2005
Uzbekistan	20 Nov 1998	12 Oct 1999	16 Feb 2005
Vanuatu		17 Jul 2001 a	16 Feb 2005
Venezuela		18 Feb 2005 a	19 May 2005
Vietnam	3 Dec 1998	25 Sep 2002	16 Feb 2005
Yemen		15 Sep 2004 a	16 Feb 2005
Zambia	5 Aug 1998	7 Jul 2006	5 Oct 2006
Zimbabwe		30 Jun 2009 a	28 Sep 2009

Source: UNFCCC (n.d.).

*Note 1: * indicates an Annex I Party to the UNFCCC*

*Note 2: ** indicates an Annex I Party for the purposes of the Kyoto Protocol by virtue of Article 1, paragraph 7, of the Kyoto Protocol.*

Note 3: 1. For the purpose of entry into force of the [Convention/Protocol], any instrument of ratification, acceptance, approval or accession deposited by a regional economic integration organization shall not be counted as additional to those deposited by member States of that Organization.

2. In a communication received on 30 August 2002, the Government of the People's Republic of China informed the Secretary-General of the following: In accordance with article 153 of the Basic Law of the Hong Kong Special Administrative Region of the People's Republic of China of 1990 and article 138 of the Basic Law of the Macao Special Administrative Region of the People's Republic of China of 1993, the Government of the People's Republic of China decides that the Kyoto Protocol to the United Nations Framework Convention on Climate Change shall provisionally not apply to the Hong Kong Special Administrative Region and the Macao Special Administrative Region of the People's Republic of China. Further, in a communication received on 8 April 2003, the Government of the People's Republic of China notified the Secretary-General of the following: "In accordance with the *provisions of Article 153 of the Basic Law of the Hong Kong Special Administrative Region of the People's Republic of China of 1990, the Government of the People's Republic of China decides that the United Nations Framework Convention on Climate Change and the Kyoto Protocol to the United Nations Framework Convention on Climate Change shall apply to the Hong Kong Special Administrative Region of the People's Republic of China. The United Nations Framework Convention on Climate Change continues to be implemented in the Macao Special Administrative Region of the People's Republic of China. The Kyoto Protocol to the United Nations Framework Convention on Climate Change shall not apply to the Macao Special Administrative Region of the People's Republic of China until the Government of China notifies otherwise." In a communication received on 14 January 2008, the Government of the People's Republic of China notified the Secretary-General of the following: In accordance with Article 138 of the Basic Law of the Macao Special Administrative Region of the People's Republic of China, the Government of the People's Republic of China decides that the Kyoto Protocol to the United Nations Framework Convention on Climate Change shall apply to the Macao Special Administrative Region of the People's Republic of China.*

3. *With a territorial exclusion to the Faroe Islands.*
4. *For the Kingdom in Europe.*
5. *With the following declaration: ".....consistent with the constitutional status of Tokelau and taking into account the commitment of the Government of New Zealand to the development of self-government for Tokelau through an act of self-determination under the Charter of the United Nations, this ratification shall not extend to Tokelau unless and until a Declaration to this effect is lodged by the Government of New Zealand with the Depositary on the basis of appropriate consultation with that territory."*
6. *By a communication received on 27 March 2007, the Government of Argentina notified the Secretary-General of the following: The Argentine Republic objects to the extension of the territorial application to the Kyoto Protocol to the United Nations Framework Convention on Climate Change of 11 December 1997 with respect to the Malvinas Islands, which was notified by the United Kingdom of Great Britain and Northern Ireland to the Depositary of the Convention on 7 March 2007. The Argentine Republic reaffirms its sovereignty over the Malvinas Islands, the South Georgia and South Sandwich Islands and the surrounding maritime spaces, which are an integral part of its national territory, and recalls that the General Assembly of the United Nations adopted resolutions 2065 (XX), 360 (XXVIII), 31/49, 37/9, 38/12, 39/6, 40/21, 41/40, 42/19 and 43/25, which recognize the existence of a dispute over sovereignty and request the Governments of the Argentine Republic and the United Kingdom of Great Britain and Northern Ireland to initiate negotiations with a view to finding the means to resolve peacefully and definitively the pending problems between both countries, including all aspects on the future of the Malvinas Islands, in accordance with the*

Charter of the United Nations.

7. *On 4 April 2006, the Government of the United Kingdom informed the Secretary-General that the Protocol shall apply to the Bailiwick of Guernsey and the Isle of Man. On 2 January 2007: in respect of Gibraltar. On 7 March 2007: in respect of Bermuda, Cayman Islands, Falkland Islands (Malvinas) and the Bailiwick of Jersey.*

CHAPTER 5

The Role of Regime Elements on the Performance of IEAs

This chapter examines regime elements affecting the environmental and economic effectiveness of IEAs by focusing on their legalization and flexibility. To consider various types of pollutants and nature conservation, it uses the databases of 123 IEAs under twenty-three international environmental regimes. The environmental effectiveness of each IEA is taken from the results of Böhmelt and Pilster (2010), based on the IRD. Environmental effectiveness is generated from the matched difference-in-difference analysis using 209 countries. The study then identifies the determinants affecting economic and environmental effectiveness of IEAs using the Bayesian probit model. The results show that the legalization element has a negative effect on environmental performance, while legally binding IEAs show a significant improvement of economic performance. On the other hand, the results of flexibility elements reflect a positive effect both in the environmental and economic models. This shows the possibility to accomplish establishing IEAs to simultaneously enable economic development to proceed in a sustainable manner and environmental improvement to be embodied in flexibility mechanisms.

5.1 Introduction

In recent years, environmental issues have risen to the forefront in international politics, concurrent with the trend of increasing regionalization and globalization (Campbell, 2004; Kanie, 2007). Consequently, global interest in the development and formation of international environmental governance aimed at improving environmental problems has also increased, along with the number of IEAs, legally binding instruments to address environmental concerns. Nevertheless, there is much room for discussion about whether IEAs have a positive effect on practical emission reduction and what determinants affect the effectiveness of such agreements.

There exist a number of previous and ongoing studies examining the effectiveness of IEAs (Aakvik & Tjøtta, 2010; Helm & Sprinz, 2000; Murdoch et al., 1997; Ringquist & Kostadinova, 2005; Kim et al., 2012; Vollenweider, 2013) and treaty design for more effective international environmental institutions (Böhmelt & Pilster, 2010; Breitmeier et al., 2006; Mitchell, 2004; Tanaka & Matsuoka, 2010). However, in the case of international environmental policy, the validity and effectiveness of IEAs are questioned on three points: participating countries have different domestic circumstances; central leadership is absent; and policy objectives are uncertain. Furthermore, the limited number of samples and data used in past studies is assumed in the propositions of existing analysis on the topic. Therefore, debates have continued throughout previous studies on the effectiveness of IEAs, unanswered questions remain about the effectiveness of IEAs, even while some scholars contend that IEAs have proven to be effective on improving environmental performance.

Despite remaining questions, previous literature has derived and described determinants of effective IEAs (Böhmelt & Pilster, 2010; Tanaka & Matsuoka, 2010). For instance, quantitative analyses about conditions of effective IEAs have attempted to conduct statistical analysis using the database of various IEAs. Böhmelt and Pilster (2010), who observe the influence of legalization and flexibility on the effectiveness of various IEAs, argue that precision of IEAs, which is one of the legalization variables and the flexibility in regime bodies, have a positive effect on environmental performance. Tanaka and Matsuoka (2010) determine that sanctions mechanisms and financial assistance have positive effects on improving environment, while technical assistance has no statistically significant effect.

In previous studies, the results indicate that differences in the structure and characteristics of member countries, the degree to which an IEA is legally binding, and the existence of sanctions are factors that can have a significant impact on the effectiveness of IEAs. Nonetheless, these quantitative analyses are often lacking because of issues with data availability and proper methodologies. There is little numerical evidence relating constituents of regimes including institutional characteristics, making it difficult to find enough empirical evidence about the relationship between regime elements and the effectiveness of IEAs to date.

In this context, this chapter intends to answer to the third research question: *Which regime elements of IEAs have a beneficial effect on the environmental and economic performance of member countries?* Therefore, the purpose of this chapter is to analyze quantitatively regime elements of IEAs affecting environmental and economic performance of member countries. In the quantitative analysis of the previous chapter with two representative IEAs, the multifaceted effectiveness of IEAs is revealed. The results indicate that there are significant differences in the effectiveness among regimes, and influencing factors vary between the effect on environment and economy. This chapter builds on earlier works to examine more specifically the determinants of the effectiveness of IEAs.

This chapter assumes that the legalization elements of IEAs have a beneficial effect on the environment, but a negative effect on the economy, since stricter regulation for preventing environmental degradation impedes national economic development. In the case of a flexible mechanism, a positive effect on both the environmental and the economy is expected, because of more adjustable options for participating countries. To verify these hypotheses, this chapter uses the environmental effectiveness data and regime elements data from the IRD. Since there are no previous studies or data of the economic effectiveness of IEAs, a quantitative data set on the economic effectiveness of IEAs is established based on an impact evaluation technique by combining the DID and PSM methods. Then, because of the small sample size, the probit model was conducted with the Bayesian approach for estimating regime elements affecting the effectiveness of IEAs. Unlike previous studies that focused on the environmental aspects of participating countries of IEAs, the current study also considers the economic effects, to understand the effectiveness of IEAs and the determinants of effectiveness more comprehensively.

The remainder of this chapter is structured as follows. Section 5.2 offers theoretical evidence about the regime elements that influence the effectiveness of IEAs, by reviewing previous studies. Based on existing literature, hypotheses focusing on two main regime elements—legalization and flexibility—are formulated. Section 5.3 introduces about the database for the quantitative analysis of this chapter. Section 5.4 provides the methodologies for establishing the database on the economic effectiveness of IEAs and putting forward empirical evidence to support the hypothesis. Section 5.5 presents the results, which confirm that the regime elements affecting the environmental and economic effectiveness vary in elements of legalization and flexibility. The final section summarizes the results, and suggests directions for future research.

5.2 Regime Elements and Effective IEAs: Legalization and Flexibility

The major research objects of initial stage of IEAs studies was formation conditions and significance of international environmental institutions (Ringquist & Kostadinova, 2005; Young, 1989; Young, 1991). Concurrent with the growing number of IEAs, the number of studies on the effectiveness of IEAs has increased. These can be broadly classified into two types depending on the differences in analytical approach. The first type is intended to evaluate the effect of particular IEAs (i.e., empirically estimate whether or not participating in IEAs improves environmental performance of member countries). The other type analyses various IEAs together to elucidate the conditions necessary for the formation of effective agreements (Matsuoka el al, 2009; Tanaka & Matsuoka, 2010).

This chapter aims to widen the understanding of the second type of studies on the effectiveness of IEAs by providing not only theoretical backgrounds but also empirical evidence. Various prior studies have proposed theoretical arguments about the determination factors affecting the effectiveness of IEAs. Weiss and Jacobson (1998) suggest that the number of relevant actors, the influence of economic incentives, public opinion and influence of other environment regimes as an important factor in the effect of the regime. According to Wettestad (1999), the process of decision-making, devices about information provision and sanctions each has an impact on the regime performance. Similarly, Mitchell (2006) also points out the importance of institutional factors, such as the existence of sanctioning mechanism and performance-based rewards. Furthermore, Koremenos et al. (2001) note that there are five regime design variables that have to be considered for improving the regime performance. They cite membership rules, scope of issues, and centralization of tasks have to be considered. Moreover, operation rules for the institution and arrangements flexibility are regarded as important factors to design the effective regimes. Barrett (2005), who has an economic point of view, proposed that minimum participation, strategic complements, role of side payments, and trade leakage can enhance the effectiveness of IEAs.

On the other hand, existing studies that carried out quantitative analyses with actual data about factors that determine the effectiveness of IEAs remain insufficient. Sprinz and Kaan (2006) focus on the design elements of the regime and investigate what design elements have an effect on the degree of problem solving by IEAs. They verify a hypothesis that assumes that the enforcement, compliance monitoring and legalization of IEAs have a positive effect on regime effectiveness in the view point of OPS for measuring regime effectiveness. Ninety-two cases from 23 regimes from the IRD are conducted in the empirical analysis with fuzzy-set method and standard OLS regressions. The results indicate that while strong legalization mechanisms show significant effect for regime effectiveness, the results about the two other main factors, knowledge and compliance monitoring, are ambiguous.

Moreover, Böhmelt and Pilster (2010) analyze the impact of legalization and flexibility on the effectiveness of IEAs with IRD data of 23 regimes used by Sprinz and Kaan (2006). That study's regression analysis using the variables selected to represent legalization and flexibility of agreements indicate that, there is a positive impact of rule precision of legalization and flexibility in regime structure on improving pollution. However, other legalization variables, including obligation or delegation instruments (independence of the secretariat) and the flexibility of membership, decision-making, and agenda show no significant effect on environmental performance.

In addition, Tanaka and Matsuoka (2010) investigate the conditions of a valid IEA with the agreement-based panel data analysis of 14 IEAs. By applying the fixed-effect model and random-effect model, the explanatory variables on the characteristics of IEAs, which include presence or absence of sanctions and concern for the developing countries, are examined. The analysis results show that monetary support and the existence of a sanction mechanism are effective in improving environmental performance, while technical support is not statistically significant. Likewise, Tanaka and Kim (2013) estimate the effect of each attribute of ratified countries and the IEA on environmental improvement by applying the IV method, which can control the endogeneity. Through the analysis about two waste related treaties and 15 air pollution related treaties, which have been adopted or entered into force since the late 1970s, a variety of attributes, such as the number of ratified countries, the terms of capacity building, and the existence of sanctions influence IEA effectiveness.

Given these studies, the current analysis attempts to determine which regime elements trigger the effectiveness of IEAs through quantitative methodology based on the Bayesian approach. This chapter focused on legalization and flexibility theory for categorize regime elements in order to examine the effectiveness of IEAs on the environments and economies of member countries and shed light on the underlying factors influencing the validity of IEAs.

Based on the database about various IEAs, this chapter is expected to complement the empirical evaluations in previous chapters. Unlike the existing research that focuses only on the effect of IEAs environmental improvement, analysis of this chapter also considers the economic impact. Thus, it is possible to provide new insights on the effect of IEAs. Furthermore, while previous chapters focused on the overall effectiveness on the specific IEAs, this chapter pays attention to determining whether flexibility and legalization, which are representative regime elements of IEAs, are influential on pollutant reduction and economic growth of participants. For example, the analysis of Chapter 4 contributes to investigating the environmental and effectiveness of the Kyoto Protocol itself; however, it is difficult to grasp which regime elements of IEAs have any effect on both aspects in that study element. Hence, even though the Kyoto Protocol installed market-based flexibility mechanisms, it is hard to identify those flexibility factors as one of causes of the non-robust economic effectiveness result.

5.2.1 Legalization Mechanism. First, the term "legalization" is defined as "a particular form of institutionalization characterized by three components: obligation, precision, and delegation" based on Abbott et al. (2000), which provide a comprehensive understanding about the variability and the dimensions of legalization from a world politic point of view. They also explain concretely about the meaning of each factor:

> Obligation means that states or other actors are bound by a rule or commitment or by a set of rules or commitments. Specifically, it means that they are legally bound by a rule or commitment in the sense that their behavior there under is subject to scrutiny under the general rules, procedures, and discourse of international law, and often of domestic law as well. Precision means that rules unambiguously define the conduct they require, authorize, or proscribe. Delegation means that third parties have been granted authority to implement, interpret, and apply the rules; to resolve disputes;

and (possibly) to make further rules. (p. 401)

Therefore, this chapter also follows these three elements of legalization while making an interpretation of IEA perspective based on Abbott et al. (2000). First, Abbott et al. (2000) introduce indicators of obligation as shown in Table 5.1.

Table 5.1 ***Indicators of Obligation***

High
Unconditional obligation; language and other indicia of intent to be legally bound
Political treaty: implicit conditions on obligation
National reservations on specific obligations; contingent obligations and escape clauses
Hortatory obligations
Norms adopted without law-making authority; recommendations and guidelines
Explicit negation of intent to be legally bound
Low

Source: Abbott et al. (2000).

This chapter defines obligation as the degree of legal binding, per Böhmelt and Pilster (2010) that define the obligation as bondage and commitment of a regime, based on Abbott et al. (2000). Therefore, it can be determined as a hard law, such as language and other defined indication of unconditional obligation, or a soft law, which imposes less obligation.

Precision means whether the regime is easy to understand, or ambiguous. As Abbott et al. (2000) state, “a precise rule specifies clearly and unambiguously what is expected of a state or other actor (in terms of both the intended objective and the means of achieving it) in a particular set of circumstance" (p. 412). In other words, a highly elaborate rule about contexts and actions of the regime is determined to be a precise rule. They insist that determinate rules about specific issues present a high degree of precision, while a regime for which it is difficult to determine whether conduct complies is an example of an ambiguous rule. Table 5.2 presents an example of indicators of precision. According to Abbott et al. (2000), regime can be regarded as precise regime if a rule is explained in narrow and limited issues.

Table 5.2 ***Indicators of Precision***

High
Determinate rules: only narrow issues of interpretation
Substantial but limited issues of interpretation
Broad areas of discretion
"Standards": only meaningful with reference to specific situations
Impossible to determine whether conduct complies
Low

Source: Abbott et al. (2000).

Finally, delegation is related to institutions that represent their authority. In Abbott et al. (2000)'s discussion, the example of a low level of delegation is diplomacy, while international court or organization represent a high level of delegation. Table 5.3 provides a more detailed discussion about delegation.

Table 5.3 ***Indicators of Delegation***

a. Dispute resolution
High
Courts: binding third-party decisions; general jurisdiction; direct private access; can interpret and supplement rules; domestic courts have jurisdiction
Courts: jurisdiction, access or normative authority limited or consensual
Binding arbitration
Nonbinding arbitration
Conciliation, mediation
Institutionalized bargaining
Pure political bargaining
Low
b. Rule making and implementation
High
Binding regulations; centralized enforcement
Binding regulations with consent or opt-out
Binding internal policies; legitimation of decentralized enforcement
Coordination standards
Draft conventions; monitoring and publicity
Recommendations; confidential monitoring
Normative statements Forum for negotiations
Low

Source: Abbott et al. (2000).

There are several ways to exercise authority in the process of dispute resolution, rule making, and implementation. This study focuses on a secretary of the IEA, since the secretary is one of the factors that represents the institutional characteristic of an IEA (Easterly & Pfutze, 2008). Resolving conflict and establishing and implementing specific rules about IEAs are usually conducted through their secretaries. Thus, in terms of IEAs, the characteristic of having a secretariat of the regime can be used to denote delegation.

From this discussion, hypotheses about legalization are established based on the literature review. Scholars who have considered the elements of legalization indicate that more legalized regimes are perceived as having better performance. Sprinz and Kaan (2006) who conducted empirical analysis to investigate which regime elements, among enforcement, compliance monitoring, legalization, and knowledge, have a positive effect on regime effectiveness, found that only legalization mechanisms of IEAs are positively related with effectiveness.

More specifically on the elements of legalization, Hafner-Burton and Tsutsui (2005), and Böhmelt and Pilster (2010), insist that there is a beneficial effect of legal binding force on the effectiveness of IEAs. Hafner-Burton (2005) also demonstrates that hard law is more effective, because soft law has limitations in holding delegates accountable for the relevant conversation. Concerning the delegation mechanism, Böhmelt and Pilster (2010) indicate that less developed or nonexistent delegation mechanisms of regimes can become barrier factors, since such regimes require extensive time and cost for decision-making and consultation. In this context, this chapter assumes a positive effect on the environment, and a negative effect on the economy, because of stricter regulations for preventing decline in the environment.

Hypothesis 1-1: *Legalization mechanisms are likely to have a positive impact on environmental performance of member countries.*

Hypothesis 1-2: *Legalization mechanisms are likely to have a negative impact on economic performance of member countries.*

5.2.2 Flexibility Mechanism. Next, flexibility mechanism is another main concept in this chapter. When the concept of flexibility is referenced in the field of IEAs, market-based flexibility instruments of the Kyoto Protocol, such as "Emission Trading System" (which is highly acclaimed for the overall reduction in greenhouse gases) are cited as examples. In this chapter, the concept of flexibility embraces not only flexibility instruments but also flexibility in matters of procedure that can influence the implementation of IEAs. This definition is in line with Böhmelt and Pilster (2010). They define the concept of flexibility as "procedural opportunities for transcending initial constraints" (p. 249) based on Wettestad (1999), who demonstrates the conditional keys for designing effective environmental regimes. Accordingly, the current analysis considers the flexibility with regard to the regime body, decision-making, agenda, and membership.

Specifically, regime body flexibility reflects the type of decision-making bodies that control regime behavior. Decision-making flexibility is the efficiency of decision-making procedure, and agenda flexibility is judged by the flexibility of topics. Lastly, the characteristic of decision-making group of authority is estimated as the membership flexibility. Each of these factors is intrinsically related to the authority of member countries. Therefore, Böhmelt and Pilster (2010) also emphasize the possibility of member countries' sovereignty and redefine flexibility mechanisms as follows:

> Flexibility mechanisms directly address countries' concerns about sovereignty, power sharing and enforcement. While still operating within the framework of a regime, they intend to increase the independence of states to deal with an environmental problem. The emission trading system of the Kyoto Protocol, opting-out clauses or changes in decision making provide examples of this. (p. 250)

Academic discussions related to the relationship between regime flexibility and effectiveness are still controversial; however, previous studies have made an effort to determine a positive effect on improving effectiveness. For example, Kucik and Reinhardt (2008) demonstrate that it is possible to adjust to new circumstances rapidly, with flexible mechanisms. Similarly, Rosendorff and Milner (2001) state that flexibility mechanisms provide the possibility for avoiding external shock or obstacles that negatively affect the implementation of IEAs. In other words, flexibility mechanism in IEAs can mitigate obstructive factors and enhance a regime's effectiveness. Kanie (2007) indicates that in consideration of "sustainable development", flexibility mechanisms for self-innovation can promote sustained economic growth:

A diffused MEA system provides secretariats with opportunities and flexibility for self innovation. It also allows a certain degree of freedom for secretariats to cooperate with agencies dealing with issues other than the environment, where such opportunities exist. Even competition over limited resources often creates positive effects as it encourages the secretariats and other agents to continuously assess their mandates and improve their performances and competencies. Some analysts also see positive effects when host countries of MEA secretariats inject stronger political will in a particular issue (ownership). (p. 74)

Wendt (2001) and Böhmelt and Pilster (2010) also insist that flexible mechanisms, such as positive incentives by flexibility, can enhance the effectiveness of IEAs. In this regard, one can anticipate a positive effect of flexible mechanisms, not only on the environment but also on the economy because of providing more adjustable options and enhancing autonomy of participating countries within the framework of IEAs. Therefore, hypotheses about flexibility mechanisms are:

Hypothesis 2-1: *Flexibility mechanisms are likely to have a positive impact on environmental performance of member countries.*

Hypothesis 2-2: *Flexibility mechanisms are likely to have a positive impact on economic performance of member countries.*

In summary, the hypotheses about legalization mechanisms anticipate a positive effect on environmental performance, while a negative effect on economic growth is predicted. The hypotheses about the flexibility elements assume a positive effect on both the environment and economy. Table 5.4 presents the hypotheses of this chapter briefly.

Table 5.4 ***Hypotheses of This Chapter***

	Environment	**Economy**
Legalization	+	-
Flexibility	+	+

Source: Author.

Note: "+" indicates a positive effect, while "-" indicates a negative effect on the environment and economy.

In addition, the one of the points that must be considered in performing the analysis about the effectiveness of IEAs is a variety of environmental problems that the IEAs are intended to address. Previous studies, which focus on categorizing by characteristics of the environmental problems, claimed that it is crucial not to overlook dissimilarities among environmental issues (Matsuoka et al., 1998; Matsuoka, 2004). In the previous analysis in Chapter 3, the empirical results reveal the possibilities of the influence of different pollutants. Therefore, this chapter also considers this point. Specific information about how this aspect is considered in the analysis process is explained in the following section.

Even now, previous studies on the determinants of the effectiveness of IEAs, especially quantitative analysis, are not sufficient. In order to build more effective international environmental governance, the examination of the effectiveness of the current institutions and the conditions of valid IEAs deserve simultaneous consideration. To attain this end, it is required to analyze using diverse and numerous IEAs. To explore the effectiveness as an object of various IEAs, the diversity of environmental problems also has to be contemplated.

5.3 Data Description

This study uses Böhmelt and Pilster (2010), based on the IRD database (Breitmeier et al., 2006) to estimate the effect of various IEAs on the environment and economy, and to determine which regime elements have a positive effect on the effectiveness of IEAs. Most previous studies about the effectiveness of IEAs are case studies because of data availability and reliability. It is true that it is difficult to find a quantitative database that contains wide information about IEAs. In this context, scholars have tried to establish numerical data, which can be analyzed quantitatively, for contributing toward the development of regime studies. Accordingly, the IRD was produced with the support by U.S. National Science Foundation and to the German-American Academic Council Foundation. More specifically, Breitmeier et al. (2006) provide information about their data as follows:

IRD is a computerized information system containing a wide variety of information

> on a continuously growing set of international regimes. The database is a research tool intended, in the first instance, for use by social scientists seeking to expand knowledge regarding the formation, effectiveness, and dynamics of regimes. The value of this knowledge to practitioners responsible for establishing and operating specific regimes should also be substantial. (p. 3)

The IRD represents a significant contribution to the field of IEA study, since it represents the first effort to compile relatively objective and comprehensive information about international environmental regimes. This database offers a wide range of quantitative data by survey of several experts on international environmental regimes of multiple features, including information on regime formation, regime attributes, regime consequences, and regime dynamics. Eighty-eight regime components and 124 collective action problems of 23 international environmental regimes (from the Whaling Regime to the Kyoto Protocol, which is covered 1946–1982 and 1997–1998, respectively) are included in the IRD. Twenty-three international environmental regimes of the IRD, which is covering both industrial pollution type and nature conservation type, are shown in Table 5.5. With regard to the environmental problems of each regimes is offered in Appendix 5.1.

Table 5.5 ***Regimes in the IRD***

Regimes	
Antarctic Regime	International Regulation of Whaling
Baltic Sea Regime	London Convention Regime
Barents Sea Fisheries Regime	Long-Range Transboundary Air Pollution
Biodiversity Regime	North Sea Regime
CITES	Oil Pollution Regime
Climate Change Regime	Protection of the Rhine Against Pollution
Danube River Protection	Ramsar Regime
Desertification Regime	Regime for Protection of the Black Sea
Great Lakes Management Regime	South Pacific Fisheries Forum Agency Regime
Hazardous Waste Regime	Stratospheric Ozone Regime
IATTC Regime	Tropical Timber Trade Regime
ICCAT Regime	

Source: Breitmeier et al. (2006).

Even though the IRD consists of survey results from experts, this is the first computerized data protocol that can be applied to the quantitative analysis. The IRD data protocol contains computerized information on international environmental 23 regimes that are described by 48 scholars who tried to answer about each IEA only when they could respond with confidence for the reliability of the information. Therefore, it is expected that this IRD data can encourage social scientists to extend their knowledge about the environmental regimes with quantitative analysis. Böhmelt and Pilster (2010), who intend to widen the understanding of international environmental regimes and their performance by empirical models, select variables for investigating the impact of both legalization and flexibility on regime effectiveness. They calculate the mean of a single variable to control for bias using the answer of all experts.

In this chapter, the variables from Böhmelt and Pilster (2010) are used for the empirical analysis, since this analysis focused on the regime elements that are represented with legalization and flexibility. The data used in the analysis contain 123 IEAs eventually, since protocols and treaties that belong to 23 regimes have been sorted by period-specific and different purposes, with parts of regimes judged by more than one expert. Although the analysis targets of environmental effectiveness cover all 123 IEAs, only 112 IEAs from 1970 to 2008 are used for the impact assessment of economic effectiveness, because of data constraints. All IEAs used in the analysis of this chapter is presented in Appendix 5.2.

Table 5.6 presents sources of the data used in the analysis of this chapter.

Table 5.6 ***Sources of Data***

Variables	Sources
Status of participating in IEAs	IEA Database Project (Mitchell, 2013), UNEP (2005)
Environmental effectiveness of IEAs	IRD (Breitmeier et al., 2006), Böhmelt and Pilster (2010)
Regime elements of IEAs	IRD (Breitmeier et al., 2006), Böhmelt and Pilster (2010)
Social factors (GDP, Population, primary, secondary industries, trade)	WDI (World Bank, n.d.)

Source: Author.

5.3.1 Dependent Variables. This study is intended to perform the quantitative analysis on regime elements bearing on the effectiveness of IEAs with regard to environmental improvement and economic growth. For this purpose, it is necessary to construct a quantitative data set on the environmental and economic effectiveness of each IEA to generate the database for the dependent variables. In this analysis, the selected variables from the IRD are adopted as the environmental effectiveness. However, the data of the economic effectiveness are generated by the impact evaluation method.

First, the environmental effectiveness is defined as whether participation in IEAs is effective for environmental improvement. Obviously, it is ideal to measure environmental effectiveness as the change in environmental performance of actual targets of each IEA. However, because of the limitation of data availability, environmental performance data is concentrated on certain types of pollution, such as air pollution; thus, it is impossible to cover the full variety of environmental performance related to IEAs. As a result, analyzing the environmental impact of various IEAs quantitatively is known to be difficult practically.

In this context, this study uses data of Böhmelt and Pilster (2010), which is based on the IRD (Breitmeier et al., 2006), consisting of data on environmental improvement effect of IEAs. In the IRD, two questions relate to the impact of IEAs on a problem that are estimated by experts by judging from documents, articles or books, interview notes and so on. According to Breitmeier et al. (2006), the IRD considers the regime to have a positive causal influence; however, “if the actual state of affairs is somewhat positive but the situation would have been even better in the absence of the regime, we consider the regime to have had a negative causal influence” (p. 137).

PROBLEM_CHANGE of the IRD equates to the answer to the question “whether and how the state of the world changed during this period with respect to the problem” (p. 137). In the IRD, there is a five-point scale for answering, in addition to options 0 for “not applicable” and 6 for “don't know”. Experts can choose the answers from these five options: the problem worsened considerably, the problem worsened slightly; the problem stayed the same, the problem improved slightly and the problem improved considerably. PROBLEM_CHANGE_CAUSAL concerns the response to the question “whether the regime exerted a causal influence on the change of the world with regard to the problem” (p.138). Again, in addition to 0 for “not applicable” and 6 for “don't know”, five possible answers are provided as follows: little or no causal impact, modest causal influence, balanced causal influence, significant causal influence and very strong causal influence.

Böhmelt and Pilster (2010) obtain variables from -1 to +1 through the process of standardizing these two variables of the IRD on the environmental effectiveness assessment by experts: PROBLEM_CHANGE and PROBLEM_CHANGE_CAUSAL. Here, the nearer to -1 means deterioration of environmental performance, while the nearer to +1 means the improvement of environmental quality. In order to focus on the determinants of effective

IEAs, this study restructured the data as binary data, indicating 0 for IEAs that are not able to confirm improvement of environmental performance, and 1 for IEAs where the improvement of environmental performance is observed.

Second, economic effectiveness is defined as whether the participation in the IEA has a positive effect on economic growth of participating countries. Since there is no previous quantitative study on the economic effect of various IEAs, this chapter measured the economic effect of each IEA by the impact evaluation technique that combines the PSM and DID methods which is applied in Chapter 3 and Chapter 4 for estimating the environmental and economic effectiveness of IEAs. Subsequently, binomial data were constructed, as 1, if the IEA has a positive effect on GDP; or 0, otherwise; as well as the data of environmental effectiveness.

To determine the status of participating countries used for measuring the economic effectiveness of IEAs, a panel data is constructed based on the information that is provided by the IEA Database Project (Mitchell, 2013) and UNEP (2005). In addition, other variables showing the socioeconomic conditions in each country, GDP, population, and the ratio of agriculture, manufacturing, and trade data, are from WDI (World Bank, n.d.).

5.3.2 Independent Variables. The independent variables are composed of three categories: legalization, flexibility, and other control variables. The independent variables related to legalization and flexibility are selected from among the literature, and mainly from Böhmelt and Pilster (2010), who investigate the effect of IEAs on environmental quality using rescaled data of the selected variables from the IRD.

Before setting variables for the empirical analysis, it is necessary to have a look carefully about this database. First, to estimate the degree of legalization of each IEA, the obligation, rule precision, and secretariat independence variables are selected, per Böhmelt and Pilster (2010). The obligation variable is determined as "whether it is legally binding on the members, or whether it has the character of soft law (e.g. ministerial declarations, guidelines, codes of conduct)" (Breitmeier et al., 2006, p. 81). The obligation variable is binomial data, which gains 1 if there is observed a feature of hard law, or 0 for soft law. The rule precision variable concerns "whether the rule is generally precise and easy to interpret in the sense that they call for well-defined actions, or whether it is ambiguous and indeterminate" (Breitmeier et al., 2006). In other words, this variable means the ease of interpretation and elaboration of IEA rules, and presents the data from 1 (unclear) to 3 (very clear). The original IRD data is coded in five-point scale for answering in addition to 0 for "not applicable" and 6 for "don't know", Böhmelt and Pilster (2010) focus on the precision value and recoded.

The last legalization variable, the secretariat independence variable, takes values from 1 to 5. If a secretariat reveals higher independence, that means that "[t]he secretariat has broad latitude to take action independent of member approval" (Breitmeier et al., 2006, p. 100). As Easterly and Pfutze (2008) state, a characteristic of secretaries of each IEA is one of important factor that reflect the institutional characteristic of IEA. Thus, it is possible to grasp the legalization status of an IEA by focusing on how independent the secretariat is. Note that the secretariat independence variable in the protocol of the IRD is cored from 1 (highly independent) to 5 (no independence) on the contrary to Böhmelt and Pilster (2010), which takes a value from 1 (no independence) to 5 (highly independent). In addition, for identifying independence of a secretariat, only core task is focused on in the evaluation. Breitmeier et al. (2006) offer additional explanations about core tasks of a secretariat in their explanation of the IRD protocol:

> Determine the independence of the secretariat according to the latitude the secretariat has when performing its core tasks (e.g., arranging and servicing meetings of the Conference of the Parties and subsidiary bodies; performing the functions assigned by legal documents; preparing and transmitting reports based on information received from the Conference of the Parties and subsidiary bodies; preparing reports on secretariat implementation activities for the Conference of the Parties; ensuring coordination with relevant international bodies and NGOs; liaising/communicating with relevant authorities, non-parties, and international

organizations; compiling and analyzing data/ information; monitoring adherence to treaty obligations; giving guidance and advice to the parties; and consulting/ assisting) as well as when performing additional tasks or roles (e.g., its political role as pusher or laggard for regime evolution/ ratification/ compliance, its promotion of treaty to non-parties, public relations, its influence on the agenda of the regime, etc.). (p.100)

Second, the flexibility variables are composed of four types of flexibility: the flexibility of regime body, decision-making, agenda, and membership. First, the regime body flexibility variable is perceived as flexible IEA if there is a regular decision entity and a capability to adjust regime behaviors with a valid influence, and not flexible otherwise. According to Breitmeier et al. (2006), experts who participated in establishing the IRD are questioned "what decision-making bodies are provided for in the regime?" (p. 103). The data is coded 3 in the case of the existence of regular bodies (Regular meeting of conference of parties), 2 with mixed bodies, and 1 with subsidiary bodies.

Next, both the decision-making and agenda flexibility variables are measured with ranges from 0 to 2, with 2 signifying high flexibility. The decision-making flexibility variable in original IRA data has a 7-point scale: no decision rules, unanimity, consensus, weighted/ unweighted voting, qualified majority, simple majority, right to opt-out/ file objection. In the IRD, the question is "what decision rules does the regime provide for and use in arriving at decisions?” (p. 102) and Böhmelt and Pilster (2010) rescale along a 3-point scale with the example of the Whaling Regime that achieved the adoption of a new moratorium by applying majority voting, which is a more flexible decision-making process. The agenda flexibility variable is about substantive or procedural restrictions affecting the agenda, so the variable represents “whether states are rather flexible in discussing and dealing with topics of interest” with the question of “are there substantive or procedural restrictions affecting the issues that get on the decision-making agenda of bodies explicitly provided for?” (Breitmeier et al., 2006, p. 107).

Moreover, the membership flexibility variable is measured 1 when there is a category of consultative mechanism with more than one category of membership, which means substantial decision-making authority toward membership, and 0 for a single category of membership. This concerns the answer to the question “is there a single category of membership or are there provisions establishing more than one category of membership?” (Breitmeier et al., 2006, p. 96). Breitmeier et al. (2006) provide the example of the Antarctic Treaty System as follows:

> Some regimes provide for categories of membership. The Antarctic Treaty System distinguishes between consultative parties and ordinary parties. Only consultative parties, confined to original signatories and states undertaking substantial scientific research in Antarctica, have decision-making authority. Non-consultative parties are

> states that accede to the Antarctic Treaty but do not undertake substantial scientific research. Non-consultative parties do not have any formal decision-making authority. (p. 96)

Lastly, the current study adopted control variables based on Böhmelt and Pilster (2010). The uncertainty variable, related to the degree of uncertainty, contains values that range from 1 to 5, with a higher value indicating low-level of understanding of the environmental issues that is intended by IEAs. This variable is from the IRD variable PROBLEM_UNDERSTAND, which concerns the question "was the nature of the problem well understood?" (Breitmeier et al., 2006, p. 32). Breitmeier et al. (2006) define the degree of uncertainty as "consensus regarding the nature, causes, and consequences of the problem, and on consensus about solutions and what should be maximized in the issue area (e.g., whether the actors value protecting fish resources or harvesting a resource to provide food)" (p. 32). The IRD measures uncertainty in five scale in the following manner: 1 (very strongly established understanding), 2 (strongly established understanding), 3 (partially established understanding), 4 (low established understanding), 5 (not at all established).

The hegemony variable reflects distribution of power among IEA participating parties. Böhmelt and Pilster (2010) adopt POWER_SETTING_SYMMETRY of the IRD, which has the highest value (5) if a certain IEA is observed an issue-specific hegemony, which means a particular country, involved in regime formation with issue-specific power.

The lowest value 1 represents completely even distribution of power resources among nations. This variable is the answer from "were the nations involved in regime formation roughly symmetrical in terms of issue-specific power or did the process involve sharp differences in power resources?" (Breitmeier et al., 2006, p. 29). According to Miles et al. (2002), the distribution of power among participants in a regime is conceived as one of the main determinants of problem-solving capacity[24].

Furthermore, the group size variable, which represents the number of participating countries responsible for the environmental issues of IEAs, ranges from 1 to 6, with a maximum value of 6 for more than 120 countries and 1 for one to five nations. Last, the public goods variable is the binominal variable for whether the target of IEA is a public good or not, and takes 1 if the use of one country does not affect the other countries' goods consumption. The question of the IRD is that "does the problem involve supplying a collective good, regulating the use of a common pool resource, managing a shared natural resource, or controlling transboundary externalities?" (Breitmeier et al., 2006, p. 24).

Table 5.7 presents survey questions in the IRD for each independent variable.

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[24] Other main determinants of problem-solving capacity for regime effectiveness is 'the institutional setting (the rules of the game)' and 'the skill and energy available for the political engineering of cooperative solutions' (Miles et al., 2002).

Table 5.7 ***Survey Questions of Independent Variables***

Categories	Variables	Survey questions in the IRD
Legalization	Obligation	Whether it is legally binding on the members, or whether it has the character of soft law
	Rule precision	Whether the rule is generally precise and easy to interpret in the sense that they call for well-defined actions, or whether it is ambiguous and indeterminate
	Secretariat independence	How independent is the secretariat from the regime's members?
Flexibility	Regime body flexibility	What decision-making bodies are provided for in the regime?
	Decision-making flexibility	What decision rules does the regime provide for and use in arriving at decisions?
	Agenda flexibility	Are there substantive or procedural restrictions affecting the issues that get on the decision-making agenda of bodies explicitly provided for?
	Membership flexibility	Is there a single category of membership or are there provisions establishing more than one category of membership?
Other control variables	Uncertainty	Was the nature of the problem well understood?
	Hegemony	Were the nations involved in regime formation roughly symmetrical in terms of issue-specific power or did the process involve sharp differences in power resources?
	Group size	How many nations were regarded as being important because of their role in causing the problem?
	Public goods	Does the problem involve supplying a collective good, regulating the use of a common pool resource, managing a shared natural resource, or controlling transboundary externalities?

Source: Breitmeier et al. (2006).

Finally, in performing the analysis about the effectiveness of IEAs, one point to consider is the variety of environmental problems that the IEAs are intended to address (Matsuoka et al., 1998; Matsuoka, 2004). Accordingly, this study includes the regime characteristics variable to investigate whether there are any differences in the characteristics of targeted pollutants. This variable is also the dummy variable, in which the variable value of 1 is defined as industrial pollution type, while the value of 0 presents a nature conservation type. Here, industrial pollution type is relevant to IEAs about air pollution, marine pollution measures, solid waste management and other agreements directly related to pollution reduction. For example, the protocols of LRTAP in Chapter 3 are representative industrial pollution type IEAs, and the Basel Convention that is aimed at protecting human health and the environment from the adverse effects of hazardous wastes is also covered. On the other hand, the nature conservation type corresponds to IEAs about fishery resources conservation, ecosystem conservation and other agreements related to conserve and improvement of nature. Therefore, the Convention on Biological Diversity and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) are included in this type.

5.3.3 Improving Independent Variables. To enhance the robustness of the quantitative analysis, the database should be complemented. The database of Böhmelt and Pilster (2010), based on the IRD, has to be complemented for enhancing the robustness of quantitative analysis. For example, the dependent variables, such as the rule precision and secretariat independence variables, are coded with an ordinal scale, which show simply in order of magnitude because there is no standard of measurement of differences. Therefore, there is no information on how much or whether the variables really differ in their characteristics. Moreover, other variables, such as the obligation variable, are appended or subtracted as interval scales, since this database is based on the result of several experts' answers, so the ordinal scale cannot be added or subtracted.

Nevertheless, the previous analysis of Böhmelt and Pilster (2010) treat these kinds of variables as an interval scale that has the same differences between values similar to other previous studies. However, these kind of ordinal scale variables are better estimated with nonparametric statistics for more precise analysis results—in other words, distribution free methods, which do not rely on strict assumptions about a probability distribution of samples. Consequently, it is conceived that OLS method used in their analysis, which assumes fitting a normal distribution, is considered as methodologically dubious for use with this database. As a result, it is required to refine the database and adopt proper methodologies in order to examine which regime elements have an effect on the effectiveness of IEAs.

In this context, this chapter intends to improve the database and methodologies to gain more precise analysis results about determinants of effective IEAs. As mentioned in the previous section, the IRD is based on the survey of several experts on international environmental regime of multiple, and Böhmelt and Pilster (2010) calculate the mean for each IEAs of each period. Therefore, prior to contemplating more adequate quantitative methodology by the considering characteristics of the database, parts of the variables of the original database should be recoded to binary data. For example, all the variables in the legalization category are rescaled to reveal more obviously each characteristic of IEAs.

In the light of the data state, the variables are recoded before analyzing. First, in the category of legalization, the obligation and rule precision variables take the value 1 if the original scale is 1 and greater, and equals to 2, respectively. The secretariat independence variable is marked 1 when the original value is greater than or equal to 4. Second, the variables in the flexibility category take the value 1 when the variables are perceived as flexible mechanisms. Third, for the control variables, the uncertainty variable measures as 1 if the data on Böhmelt and Pilster (2010) is greater than or equal to 4. Note that the group size and public goods variables are used without recoding. The reason is that the group size variable can be considered as an interval scale, and the public goods variable is the dummy variable with no decimal sign. Table 5.8 depicts how the independent variables in this chapter are recoded based on the original scale.

Table 5.8 ***Recoded Independent Variables***

Categories	Variables	Original scale	Rescaled by author
Legalization	Obligation	from 1 (hard law) to 0 (soft law)	hard law=1 otherwise =0 (values < 1)
	Rule precision	from 3 (very clear) to 1 (unclear)	clear =1 (values ≥ 2) otherwise =0
	Secretariat independence	from 5 (highly independence) to 1 (no independence)	independence =1 (values ≥ 4) otherwise =0
Flexibility	Regime body flexibility	from 3 (regular body) to 1 (subsidiary body)	regular body=1 otherwise =0
	Decision-making flexibility	from 2 (high flexibility) to 0 (not flexible)	high flexibility=1 otherwise =0
	Agenda flexibility	from 2 (high flexibility) to 0 (not flexible)	high flexibility=1 otherwise =0
	Membership flexibility	from 1 (single category of membership) to 0 (not applicable)	consultative mechanism =1 (values > 0) single category =0
Other control variables	Uncertainty	from 5 (uncertainly) to 1 (certainty)	uncertainty=1 (values ≥ 3) otherwise =0
	Hegemony	from 5 (uneven distribution) to 1 (even)	uneven distribution=1 (values ≥ 4) otherwise =0
	Group size	1 = 1–5 2 = 6–15 3 = 16–30 4 = 31–60 5 = 60–120 6 = more than 120	1 = 1–5 2 = 6–15 3 = 16–30 4 = 31–60 5 = 60–120 6 = more than 120
	Public goods	public good=1 otherwise =0	public good=1 otherwise =0

Source: Author.

Note: Original scale is based on the scales of the database of Böhmelt and Pilster (2010).

5.4 Empirical Method

This chapter is intended to perform a quantitative analysis on the effectiveness of various IEAs on environmental and economic performance and define the determinants affect those effectiveness levels. For this purpose, the analysis process of this chapter is divided into two steps: generating the economic effectiveness data and analyzing the regime elements.

The first step is a verification step for generating the quantitative data on the economic effectiveness of IEAs, since there is no quantitative analysis about the effect of various IEAs on the economy (and, consequently, there is no numerical data). The second step is to explore the determining factors with setting environmental and economic effectiveness of each agreement for the dependent variables. In this step, this chapter applies Bayesian methodology with MCMC that assume the posterior distributions on the basis of the probability of existing data for gaining more precise analysis result concerning determinants of the effectiveness of IEAs.

The analysis of the first step is conducted with STATA/SE 11.2 for Windows (32-bit) equal to Chapters 3 and 4. However, R version 3.0.2 is used for the analysis of the second step for applying the Bayesian methodology to the analysis, since STATA does not support the Bayesian approach.

5.4.1 Impact Evaluation for Economic Effectiveness. This section provides empirical models for the economic effectiveness first. The impact evaluation technique that combines the PSM and DID methods, which is applied in Chapter 3 and Chapter 4, is conducted to produce numerical data about the effect of each IEA on the economies of the participants. Since the general methodological process is already explained in previous chapters, essential practical processes are focused on in this section.

Through the process of calculating propensity score and matching from observable characteristic with the country-based panel data of each IEA, it is possible to identify countries that have statistically similar characteristics; in other words, comparable samples remain. Therefore, comparison and analysis of both participants and non-participants of IEA can be achieved in a manner that statistically reliable, since it is possible to configure the experimental populations to minimize the selection bias. In this analysis, in addition to GDP and population that represents economic and social characteristics of the country, primary industry, secondary industry, and the proportion of international trade at a ratio to GDP are applied as an observable characteristic X (Refer to Equation 3.2). With those five variables, the propensity scores are calculated in each panel data of 123 IEAs.

For the matching process, DID matching criteria is applied as in previous chapters. As mentioned in the previous chapters, if the data is available in both before and after program participation and can be secured for an experimental group and a comparison group, this criteria can be adopted for more effective matching (Khandker et al., 2010). This chapter carries out this matching analysis with the panel data of more than 200 countries from 1970 to 2008. As a result, propensity scores $\omega(i, j)$ of participating countries *i* and non-participating countries *j* are calculated. In this analysis, Y_i^T means economic performance of participating countries, while Y_i^C refers to the economic performance of non-participating countries in the two time points $t = \{1, 2\}$, which indicates before and after IEAs participation (Refer to Equation 3.4). With the samples based on the matching process, changes are observed in GDP of the participating countries and non-participating countries before and after the participation of IEAs precisely by the fixed-effect regression analysis model. It is possible to remove the problem of endogeneity with handling of a time-invariant and heterogeneity, which causes the selection bias.

Finally, to estimate the economic effectiveness of IEAs with controlling other possible factors, the rate of agriculture, exports of goods and services, trade, and population are added as the control variables based on the calculation of the propensity score. The equation of the final step for the economic effectiveness data is as follows:

$$\begin{aligned} Ln\text{GDP} = {} & \alpha_0 + \alpha_1 \text{IEA dummy} + \alpha_2 \text{Agriculture} + \alpha_3 \text{Exports} + \alpha_4 \text{Trade} \\ & + \alpha_5 \text{Population} + \alpha_6 \text{Time dummy} \end{aligned} \tag{5.1}$$

As a result of the analysis above, binary data about the effectiveness of each IEA are produced: 1 if the effect of IEA participation on the economic performance of member countries is confirmed statistically, otherwise 0. This data is combined with the modified IRD data, which is based on Böhmelt and Pilster (2010) as one of the dependent variables of the empirical analysis for the next step.

5.4.2 Probit Model for Binary Dependent Variables. By the process described above, while data on the environmental and economic effectiveness and regime elements of targeted IEAs of this study is aligned. Using the environmental and economic effectiveness of IEAs as the dependent variables, the quantitative analysis on the impact of various regime elements on the environment and economic effectiveness of IEAs is conducted based on research by Böhmelt and Pilster (2010).

As mentioned in the previous sections, when an objective variable is a binary choice, ML method, which is a nonlinear approach, is desirable, rather than OLS, since the linear model assumption cannot be established between independent variables and dependent variables, which is not a continuous variable. This binary response situation can be expressed as follows:

$$y_i = \begin{cases} 1, & \text{if } y_i^* > 0 \\ 0, & \text{if } y_i^* \leq 1 \end{cases} \tag{5.2}$$

In the equation above, y_i indicates observed value while y_i^* is latent valuable. If the linear regression model about y_i is assumed, the probability of $y_i = 1$ can be derived:

$$y_i^* = \alpha + \beta x_i + \epsilon_i$$

$$\Pr(y_i = 1) = \Pr(y_i^* > 0) = \Pr(\epsilon_i > -\alpha - \beta x_i) = F(\alpha + \beta x_i) \qquad (5.3)$$

In this equation, $F(\cdot)$ is cumulative distribution function (CDF) which gives the probability of a random variable being less than or equal to any specified real number. In this case, probit regression model or logistic regression analysis is suggested. The difference of these two models is how the possibility of particular selection $F(\cdot)$ is defined. The probit estimator is utilized if $F(\cdot)$ is assumed the standard normal CDF, and the logistic estimator is applied if $F(\cdot)$ is supposed to standard logistic CDF.

In this chapter, the probit estimator is used to compare and explain the relative influence of various elements of IEAs on the environment and economic effectiveness. If binary response variable y follows Bernoulli distribution, the probability of success is Pr (defined as CDF of standard normal distribution), which takes a value between 0 and 1. Moreover, if y_i follows the probit model, the probability of success of x_i is written as following equation. Here, $\Phi(\cdot)$ means CDF of standard normal distribution:

$$\Pr(y_i = 1) = \Phi(\alpha + \beta x_i),\ i = 1,2,\cdots,n \qquad (5.4)$$

5.4.3 Bayesian Approach for Small Sample Size. For estimation of the regime elements affecting the effectiveness of IEAs, a Bayesian approach is adopted, since there are not sufficient samples to assume parameters with classical statistical methods. The classical statistical methods, which are called frequentist statistics, consider parameters as fixed, so inferences are made based on infinitely repeated experiments and data collection. Therefore, a frequentist approach depends on large sample to gain reliable results. However, the database of this chapter contains 116 IEAs for the environmental effectiveness and 82 IEAs for the economic effectiveness, because data about the observed characteristics can be used from 1970 to 2008 in the process of impact assessment of the economic effectiveness. Consequently, it is problematic to estimate precisely through applying the frequentist statistics with this small sample.

The Bayesian methods are not based on an assumption of large sample size on the contrary to the classical statistical methods. The reason is that the classical statistical methods and the Bayesian methods stand on different philosophical positions about statistical inference. Traditional statistical methods assume the parameters of the population to be unknown constants, while Bayesian methods regard the parameters as a random variable that can be changed. Bayesian inference, which regards the parameters as the value that is possible to be quantified from past experience and expert opinion, allows information about the parameters to be expressed by the random variable distribution with the probability concept. Therefore, Bayesian statistics combines information of samples and a prior distribution to generalize a posterior distribution related to the parameters, and this posterior distribution is the basis for the Bayesian inference.

As expressed in Figure 5.1, the Bayesian approach produces the posterior distribution by Bayes' theorem, based on the likelihood function related to parameter value and prior distribution.

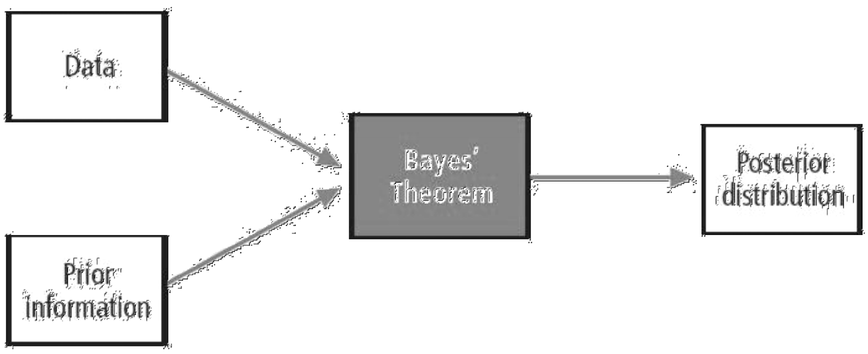

Figure 5.1 **Generating posterior distribution**

Source: Stevens (2009).

Bolstad (2011) summarizes Bayes' theorem and insists that one of an advantage of the Bayesian statistics is that the posterior distribution is estimated on the basis of only one theorem:

> A huge advantage of Bayesian statistics is that the posterior is always found by a single method: Bayes' theorem. Bayes theorem combines the information about the

parameters from our prior density with the information about the parameters from the observed data contained in the likelihood function into the posterior density. It summarizes our knowledge about the parameter given the data we observed.

To explain concretely, if the prior distribution is $p(\theta_1, \theta_2)$, and the likelihood function that reflect the distribution of prior information is defined as $p(Y|X, Z, W, \theta_1, \theta_2)$, the posterior distribution after Bayes' theorem can be expressed as follows:

$$p(\theta_1, \theta_2|X, Z, W, Y) \propto p(Y|X, Z, W, \theta_1, \theta_2)p(\theta_1, \theta_2) \quad (5.5)$$

Likewise, since the Bayesian methods use a posterior distribution for statistical inference, neither an assumption of normal distribution or an assumption of large sample size are required.

In this analysis, the Bayesian approach with MCMC by Gibbs sampling is applied for the analysis. In addition, this method assumes a conjugated prior distribution; thus, it is supposed that the prior distribution has equal distribution of the posterior distribution. As Martin and Quinn (2006) mentioned, "MCMC methods provide a fairly straightforward way for one to take a random sample approximately from a posterior distribution. Such samples can be used to summarize any aspect of the posterior distribution of a statistical model" (p. 2). According to Casella and George (1992), MCMC use the estimation of $\mathrm{p}(\theta_1, \theta_2|X, Z, W, Y)$

of i for the estimation of $i+1$, and the estimation about the posterior distribution of $p(\theta_1, \theta_2 | X, Z, W, Y)$ is repeated until convergence. In the process of MCMC, Gibbs sampling estimates the conditional posterior distribution between $\theta_1 | \theta_2$ and $\theta_2 | \theta_1$ first, and then estimates the joint posterior distribution of (θ_1, θ_2). Casella and George (1992) provide the brief explanation about the Gibbs sampler:

> The Gibbs sampler is a technique for generating random variables from a (marginal) distribution indirectly, without having to calculate the density. Although straightforward to describe, the mechanism that drives this scheme may seem mysterious. [...] In such cases, it is easy to see that Gibbs sampling is based only on elementary properties of Markov chains. (p. 167)

It is noteworthy that extracted random numbers before convergence should be excluded from the analysis, since random numbers by the Gibbs sampling method do not follow joint distribution precisely. Theoretically, it is known that when this process is repeated numerous times, these random numbers converge to the joint distribution. Therefore, the burn in time, which means the time required until convergence, has to be considered in the process of estimation. In the analysis of this chapter, the "burn in" option and the MCMC option, which control the "number of burn in iterations for the sampler" and the "number of Gibbs iterations for the sample", respectively, are used for excluding random numbers before convergence (Martin et al., 2013).

More practically, this chapter applies a command of "Markov Chain Monte Carlo for Probit Regression (MCMCprobit)" of "MCMCpack" (MCMCpack, n.d.), which is targeted at social scientists (Martin & Quinn, 2006) in the statistical program R for assuming the Posterior Distribution. "MCMCpack" is made for a formal R package with which users can perform Bayesian inference via MCMC. Martin et al. (2011), who are the inventors of this program, offer a brief introduction of "MCMCpack":

> MCMCpack is an R package that contains functions to perform Bayesian inference. It provides a computational environment that puts Bayesian tools (particularly MCMC methods) into the hands of social science researchers so that they (like statisticians) can fit innovative models of their choosing. Just as the advent of general purpose statistical software (like SPSS and SAS) on mainframe and then personal computers led to the widespread adoption of statistical approaches in the social sciences, providing easy-to-use general purpose software to perform Bayesian inference will bring Bayesian methods into mainstream social science. (p. 2)

"MCMCprobit" estimates from the posterior distribution of a probit regression model using data augmentation. The specific information on a probit regression of the Bayesian approach is provided in Martin et al. (2013). They demonstrate that "[t]his function generates a sample from the posterior distribution of a probit regression model using the data augmentation approach of Albert and Chib (1993)". Therefore, "[t]he user supplies data, priors, and a sample from the posterior distribution are returned as a MCMC object, which can be subsequently analyzed with functions provided in the coda package" (p. 105).

After conducting the estimation of a probit regression in the Bayesian approach, the result is presented to intervals of probability that contain the true value or that the probability of the hypothesis is true. Generally, the posterior mean is used for inference of estimation of parameter value and the posterior median can be used in the case of an asymmetric posterior distribution. In the Bayesian estimation, the probability interval means the credible interval. The statistical analysis by "MCMCprobit" command by R provides the quantile of 97.5% and 2.5%, which indicates the credible interval of 95%. In other words, if a certain credible interval is given, it can be interpreted as the probability of the existence of a parameter included in this credible interval being 95%. Accordingly, in the probit model of the Bayesian approach, the result can be regarded as statistically significant if the 95% credible interval does not include zero. With this in mind, this chapter also consider statistical significance if 95% credible interval does not contain zero.

Finally, the analysis to investigate what regime elements have an effect on the environmental effectiveness and economic effectiveness of IEAs is conducted. The equations are derived as follows. In these equations, Y of the first equation indicates the environmental effectiveness and Z of the second equation means the economic effectiveness:

$$Y = \beta_0 + \beta_1(\text{Obligation}) + \beta_2(\text{Rule precision}) + \beta_3(\text{Secretatiat independence})$$
$$+\beta_4(\text{Regime body flexibility}) + \beta_5(\text{Decision making flexibility})$$
$$+\beta_6(\text{Agenda flexibility}) + \beta_7(\text{Membership flexibility}) + \beta_8(\text{Uncertainty})$$
$$+\beta_9(\text{Hegemony}) + \beta_{10}(\text{Group size}) + \beta_{11}(\text{Public goods}) + \beta_{12}(\text{Charicteristic}) \quad (5.6)$$

$$Z = \gamma_0 + \gamma_1(\text{Obligation}) + \gamma_2(\text{Rule precision}) + \gamma_3(\text{Secretatiat independence})$$
$$+\gamma_4(\text{Regime body flexibility}) + \gamma_5(\text{Decision making flexibility})$$
$$+\gamma_6(\text{Agenda flexibility}) + \gamma_7(\text{Membership flexibility}) + \gamma_8(\text{Uncertainty})$$
$$+\gamma_9(\text{Hegemony}) + \gamma_{10}(\text{Group size}) + \gamma_{11}(\text{Public goods}) + \gamma_{12}(\text{Charicteristic}) \quad (5.7)$$

The final models of this chapter contain the twelve independent variables. The obligation, rule precision, and secretariat independence variables are included for the legalization category. Moreover, the flexibility of regime body, decision-making, agenda, and membership variables are also included for the flexibility category. For the control variables, the uncertainty, hegemony, group size, public goods, and characteristic variables are considered. Please refer to Section 5.3 (Data Description) for more details on each of these.

Table 5.9 provides descriptive statistics of each variable. Since the data of the environmental and economic effectiveness are gained from 116 and 82 IEAs respectively, the number of IEAs that were included in the final probit analysis is fewer than 123.

Table 5.9 ***Descriptive Statistics***

Variables	N	Mean	SD	Min	Max
Environmental effectiveness	116	0.388	0.489	0	1
Economic effectiveness	82	0.159	0.367	0	1
Obligation	116	0.681	0.468	0	1
Rule precision	116	0.422	0.496	0	1
Secretariat independence	123	0.228	0.421	0	1
Regime body flexibility	117	0.350	0.479	0	1
Decision-making flexibility	114	0.061	0.241	0	1
Agenda flexibility	116	0.388	0.789	0	1
Membership flexibility	116	0.379	0.487	0	1
Uncertainty	123	0.285	0.453	0	1
Hegemony	119	0.168	0.376	0	1
Group size	118	2.466	1.245	1	6
Public goods	123	0.431	0.497	0	1
Regime characteristics	123	0.398	0.492	0	1

Source: Author.

5.5 Results

This study aimed to carry out the quantitative analysis for investigating the determinants of IEAs from two perspectives: the environment effectiveness and the economic effectiveness. Based on the literature reviews, the hypotheses about legalization and flexibility on the environmental and economic aspect were established. First, it was assumed that there would be a positive effect on the environment but negative effect on the economy because of stricter regulation for preventing decline in environment. Concerning flexibility, it had a positive effect on both environmental and economy performance, since it can be expected that more adjustable options for participating countries are provided.

To fulfill the research purpose, the data on the influence of IEAs on the environment quality and economic growth was built first, and then in order to explore the determinants the probit models in the Bayesian approach were conducted for each economy and environment aspects. The first step of the Bayesian probit model is simulating the posterior distributions of the parameters until a convergence occurs. Subsequently, the influence of regime elements on the effectiveness of IEAs was investigated with the predicted mean of the posterior distributions. Note that the analysis models are separated as the environmental effectiveness model and the economic effectiveness model in accordance with the dependent variables.

5.5.1 Simulating the Posterior Distribution. To obtain the posterior distribution of the parameters, MCMC algorithms are conducted using 25,000 Gibbs iterations for the sampler, discarding the first 5,000 iterations as the initial iterations in burn in time that are regarded as not yet converged. Based on the convergence diagnostic test by Geweke (1991), 5,000 burns in iterations are regarded as appropriate (Geweke, 1991; Kakamu et al., 2010). All the variables are fitted with 25,000 MCMC iterations with 5,000 burns in. Figure 5.2 presents the traces of each parameter in the process of Gibbs sampling after convergence in the environmental effectiveness model. From this figures, it is identified that all parameter are converged well.

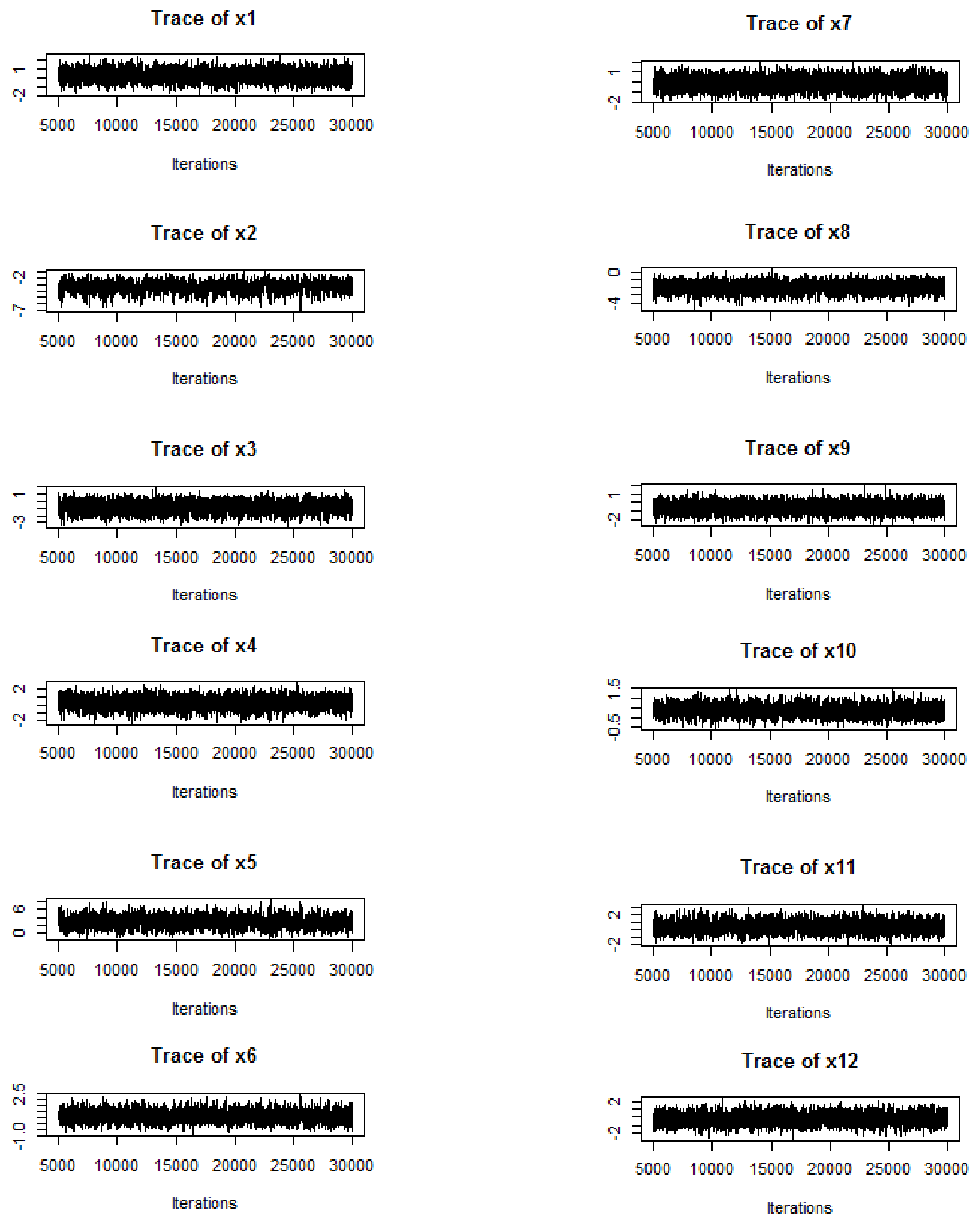

Figure 5.2 **Traces of Parameters in the Environmental Effectiveness Model**

Source: Author.

Note: $x1=\beta_1$, $x2=\beta_2$, $x3=\beta_3$, $x4=\beta_4$, $x5=\beta_5$, $x6=\beta_6$, $x7=\beta_7$, $x8=\beta_8$, $x9=\beta_9$, $x10=\beta_{10}$, $x11=\beta_{11}$, $x12=\beta_{12}$.

On the other hand, in the case of economic effectiveness, the model shows difference patterns. Notwithstanding the statistical program R indicates that all the models are fitted with 25,000 MCMC iterations with 5,000 burns in, the traces of parameters in the economic effectiveness model indicate that the convergence speed of γ is slower than the environmental model[25]. Figure 5.3 shows the traces of each parameter in the process of Gibbs sampling after convergence in the economic effectiveness model.

From this result, it is required to discard more than 10,000 iterations as the initial iterations in burn in time for more accurate analysis results. To obtain a more precise result concerning the posterior distributions of parameters, MCMC algorithms using 50,000 Gibbs iterations are conducted. However, almost identical patterns are observed with the 25,000 Gibbs iterations. Thus, based on the result (that indicates that all the models are fitted), it is decided in this chapter to estimate the posterior distributions using 25,000 iterations and discarding 15,000 iterations, even though there are some undulations observed in parts of parameters.

[25] Especially, the traces of γ_1 (obligation), γ_4 (regime body flexibility), γ_5 (decision-making flexibility), γ_6 (agenda flexibility), and γ_9 (hegemony) reveal that it is better to discard more iteration.

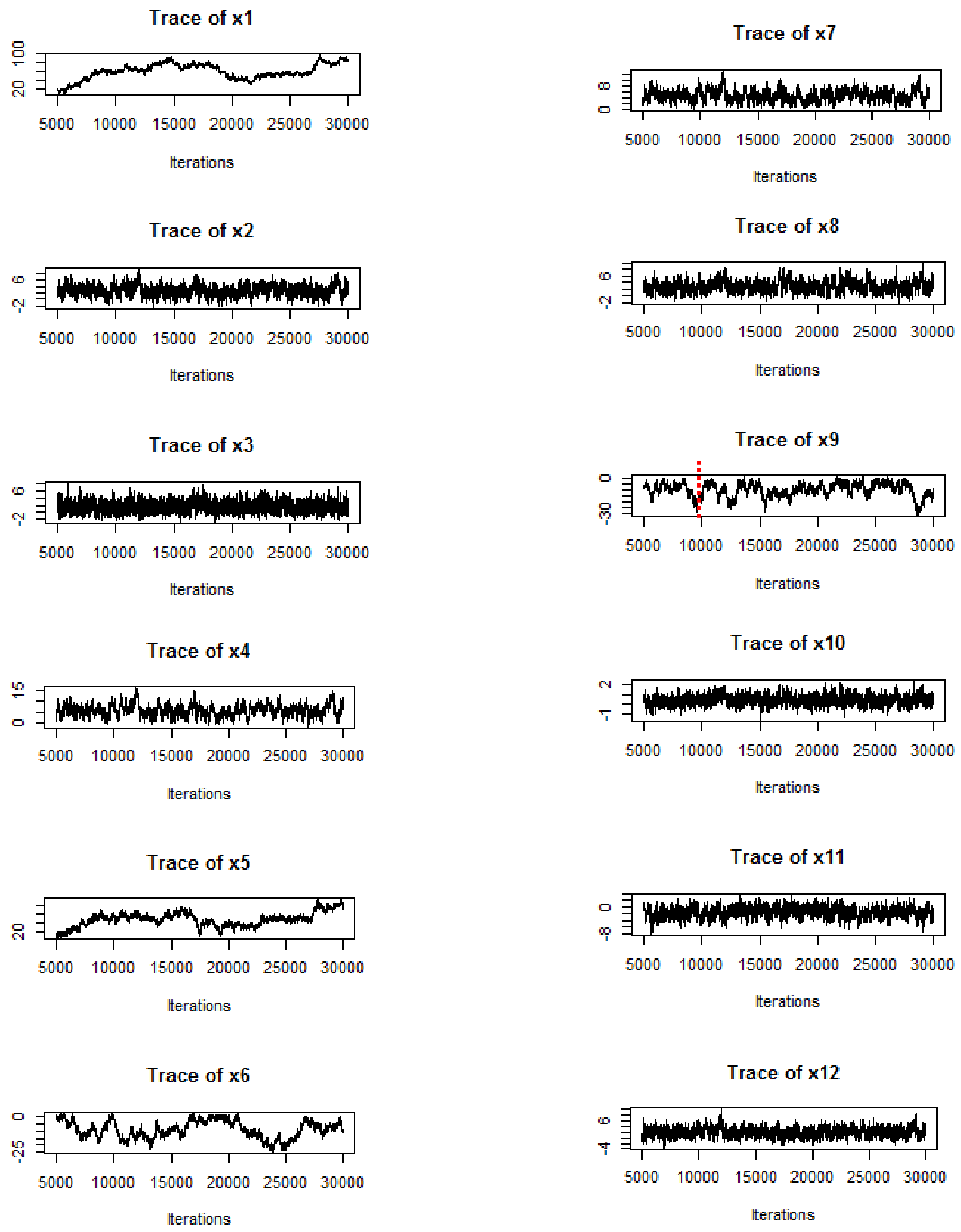

Figure 5.3 **Traces of Parameters in the Economic Effectiveness Model**

Source: Author.

Note 1: x1=γ_1, x2=γ_2, x3=γ_3, x4=γ_4, x5=γ_5, x6=γ_6, x7=γ_7, x8=γ_8, x9=γ_9, x10=γ_{10}, x11=γ_{11}, x12=γ_{12}.

5.5.2 Regime Elements Affecting the Environmental Effectiveness. Table 5.10 presents the estimation result of the environmental effectiveness model, which is intended to estimate which regime elements have an effect on environmental performance of member countries. Please refer to Appendix 5.3 for the results of the environmental effectiveness models per category.

Table 5.10 ***Results on the Environmental Effectiveness Model***

Categories	Variables	β	Mean	SD	95% HPD		
					2.50%	50.0%	97.5%
Intercept		β_0	-0.500	0.936	-2.419	-0.486	1.284
Legalization	Obligation	β_1	0.247	0.547	-0.819	0.246	1.330
	Rule precision	β_2	-3.396*	0.831	-5.177	-3.341	-1.938
	Secretariat independence	β_3	-0.877	0.649	-2.201	-0.864	0.361
Flexibility	Regime body flexibility	β_4	0.231	0.662	-1.125	0.253	1.476
	Decision-making flexibility	β_5	2.927*	1.274	0.561	2.859	5.564
	Agenda flexibility	β_6	0.667	0.407	-0.091	0.651	1.501
	Membership flexibility	β_7	-0.081	0.523	-1.108	-0.080	0.939
Other control variables	Uncertainty	β_8	-2.011*	0.583	-3.200	-2.000	-0.909
	Hegemony	β_9	-0.576	0.532	-1.630	-0.572	0.463
	Group size	β_{10}	0.377	0.257	-0.111	0.372	0.893
	Public goods	β_{11}	0.521	0.673	-0.787	0.518	1.867
	Regime characteristics	β_{12}	-0.190	0.607	-1.384	-0.189	1.000

Source: Author.
*Note: * indicates that zero is not included in the 95% credible interval.*

In the result table, Mean and SD indicate the posterior mean and the posterior standard deviation, respectively. Moreover, the column of 95% Highest Posterior Density (HPD) represents the credible interval of 95% that means the probability of the existence of a certain parameter included in this credible interval is 95%. In other words, from the process of 5,000 MCMC iterations, the posterior distributions of each parameter are estimated, and the empirical results show the shape of those distributions. Therefore, this chapter identifies the statistically significant variables according to whether the 95% credible interval contains zero or not.

The empirical results indicates that the rule precision and secretariat independence variables of the legalization category and the membership flexibility variable of the flexibility category, the uncertainty variable, the hegemony variable, and industrial pollution type have a negative effect on environmental performance. The obligation, regime body flexibility, decision-making flexibility, agenda flexibility, group size, and public goods variables influence positively on pollutant reduction. However, three regime elements of one variable by each category are statistically significant in the Bayesian probit analysis: the rule precision variable, the decision-making flexibility variable, and the uncertainty variable.

In the legalization elements, only the rule precision variable, which indicates "whether the rule is generally precise and easy to interpret in the sense that they call for well-defined actions" (Breitmeier et al., 2006, p. 82), shows that the mean of the posterior is

-3.396 and statistically significant. That is, if IEA contains more precise rules, the probability that is included in the IEA positive environmentally decreases 3.40. This result reflects that IEAs with clearer and more precise contexts are negatively correlated with environmental performance, as a result that conflicting with the empirical analysis result by Böhmelt and Pilster (2010). They insist that "[v]ague norms and regulations do not suit nations' long-term interests to protect the environment" (p. 255). Generally, from a long-term point of view, it is known that it would contribute to environmental protection policies of participating countries if the rules of an IEA are prescribed in a precise manner, as also argued by Böhmelt and Pilster (2010). However, a cautious position has been taken by Abbott et al. (2000) who insist that it is also possible that the precise rule of IEAs would constrains its policy actions or domestic policies, such as making regulations related to the environmental protection in the short term. The findings of this chapter support the negative arguments about the influence of precise regime rules. Note that the relationship between rule precision and the environmental effectiveness of IEAs remains a matter of debate.

The results of the obligation and secretariat independence variables are both statistically insignificant, consistent with the empirical evidence drawn by Böhmelt and Pilster (2010). This contradicts parts of previous studies that claimed there is a need of a legally binding treaty to improve the effectiveness of IEAs (Abbott et al., 2000; Hafner-Burton, 2005; Hafner-Burton & Tsutsui, 2005). More specifically, Abbott et al. (2000)

state that legally binding IEAs, which has a strong sense of duty, are more likely to receive corresponding legal discourse. Hafner-Burton (2005) insists that soft law is negative for the formation of an effective regime. Moreover, Hafner-Burton and Tsutsui (2005) also state that there exists beneficial effect of legal binding force on the effectiveness of IEAs. However, even though the analysis result of the obligation variable shows a positive sign, a statistically significant effect on the environmental effectiveness of IEAs is not observed in the analysis of this chapter.

Moreover, in the case of the secretariat independence variable, which reflects the degree of delegation representing authority, the result shows a negative sign, but is statistically insignificant from 95% HPD. Statistically significant results are not obtained even in the analysis of Böhmelt and Pilster (2010), who analyze the effect of the independence of the secretariat on the environmental effectiveness of IEAs. Thus, it is considered that influence of the independence of the secretariat on the environmental performance is not greater. One possible reason is that the actual authority of a secretariat of international agreements is limited. Gross and Goodrich (1964) make clear that "the functions of the secretariat are limited to administrative and technical matters" (p. 535) in the book review of *"Essai sur le Secretariat International"* by Jean Siotis.

The next category is the flexibility elements of IEAs. Scholars who focus on advantages of flexibility mechanisms of IEAs emphasize that it is possible to circumvent exogenous shocks or difficulties and rapidly adjust to new circumstances through flexible mechanisms (Kucik & Reinhardt, 2008; Rosendorff & Milner, 2001). In the empirical analysis about the flexibility elements of IEAs, only the decision-making variable is confirmed as statistically significant with a positive sign, whereas the regime body, agenda, and membership flexibility variables are found to be insignificant. That is, only the posterior of the decision-making flexibility parameter is observed positively in the credible interval of 95% with the value of 2.927. Thus, it is perceived that more environmental improvement can be achieved if a certain IEA has more flexible decision rules—in other words, more flexible decision-making process.

The result of the regime-body flexibility is not statistically significant in the full model, while it is significant in the flexibility category model. Therefore, there is room for reconsideration of the argument of Böhmelt and Pilster (2010), which contended that the regime-body flexibility has a positive effect on environmental effectiveness. They claim that, during the decision-making of IEAs, the final decision is enabled by a decision-making entity without being influenced by the preferences of the participating countries of the individual, so the environmental effectiveness of the IEAs is high. However, the empirical results of this study find a weak effect of a regular decision entity on environmental performance. Moreover, the effect of flexibility in discussing and dealing with topics of interest, and substantial decision-making authority toward membership does not have significant effect on the environmental effectiveness of IEAs.

To account for the last category related to the control variables, the result of the uncertainty variable is of interest. The environmental effectiveness positively depends on the degree of understanding of the environmental issues. From this result, it can be said that if the understanding of participating countries on environmental issues is low, which means insufficient consensus, and, thus, a negative effect is observed on environmental improvement by participating in IEAs. More specifically, the mean of the posterior distribution is -2.011, and this indicates that IEAs with a lack of understanding about the environmental problems are likely to adversely affect environmental performance of member countries. This result is almost in line with the research by Böhmelt and Pilster (2010), which investigate the negative relationship between the effectiveness of IEAs and their ambiguity. As expected, there is a positive effect on environmental improvement as consensus is obtained for environmental issues that IEAs target.

Nevertheless, other control variables have no significant effect on environmental improvement achieved by IEAs. The hegemony variable that shows the distribution of the power of the agreement has a positive sign, but no statistical significance. Hence, the evidence is not found in favor of the assumption that an IEA is effective environmentally when the power distribution of IEA among participating countries has overemphasized a specific state. Moreover, the statistical significance of the group size variable is not confirmed in this analysis. Several previous studies have concluded that there is a statistically significant effect of the number of participating countries on the effectiveness of IEAs (Barrett, 2005; Weiss & Jacobson, 1998). It has been pointed out that in the case of collective action, such as IEAs in general, achieving the objectives of the population is difficult in a large group with many members number because of the “free rider” nations (Mearsheimer, 1994; Olson, 1965). He also insists that the optimal allocation of resources is tricky due to the large number of participants increases the cost. Moreover, as in the argument of Barrett (2005), some studies claim that a minimum participation in the treaty is one of the conditions of an effective IEA. However, Barrett (2005) is not able to verify that the effect of the number of participating countries on environmental effectiveness is not statistically significant in empirical analysis.

Furthermore, the public goods variable becomes statistically insignificant in the environmental effectiveness model. Even if various discussions have been had about features of policy target and effects in prior studies, it is mainly qualitative research, such as case studies, and a unified view is not obtained. On the other hand, analysis that combines the number of participants and feature of policy target has been carried out. For example, Böhmelt and Pilster (2010) have shown that there would be more environmental improvement with a greater number of participating countries if the environmental problem is a public good, from empirical analysis of the effects of the number of participants and feature of policy target on the environmental effectiveness of IEAs. Finally, the characteristic of IEAs, which means the differences in the characteristics of targeted pollutants, has no significant effect, although a negative sign is shown. This result indicates that there is no significant difference in influence on environmental improvement between industrial pollution type and nature conservation type.

In sum, Hypothesis 1-1 that assumed that legalization mechanisms are likely to have a positive impact on environmental performance of member countries, is rejected from the empirical result of the rule precision variable. In the case of flexibility, it is revealed that the result of the decision-making flexibility variable supports Hypothesis 2-1, which supposes that flexibility mechanisms are likely to have a positive impact on environmental performance of member countries.

Overall, the differences are observed between the empirical results from the Bayesian probit model in this chapter and previous studies, especially that of Böhmelt and Pilster (2010), which conduct an OLS regression model with similar data. Since they perform a linear regression analysis with survey results of environmental effectiveness by the IRD, there is a possibility of bias from the distribution and structure of the data. Since the present study evaluates the determinants affecting environmental effectiveness using more refined data and advanced quantitative methodologies, this reliable result can reveal the real effectiveness of regime elements with a limited data set.

5.5.3 Regime Elements Affecting the Economic Effectiveness. The estimation result of the economic effectiveness model, which is intended to evaluate which regime elements affect the economic performance of member countries, is presented in Table 5.11. The more specific results of the economic effectiveness models per category are provided in Appendix 5.4.

Table 5.11 ***Results on the Economic Effectiveness Model***

Categories	**Variables**	γ	**Mean**	**SD**	**95% HPD**		
					2.50%	**50.0%**	**97.5%**
Intercept		γ_0	-78.182*	15.443	-103.323	-80.546	-48.164
Legalization	Obligation	γ_1	68.042*	14.923	38.758	70.673	93.605
	Rule precision	γ_2	2.544	1.494	-0.297	2.509	5.579
	Secretariat independence	γ_3	1.770	1.329	-0.643	1.704	4.589
Flexibility	Regime body flexibility	γ_4	5.487*	2.395	1.186	5.386	10.516
	Decision-making flexibility	γ_5	48.192*	17.277	18.873	46.881	85.446
	Agenda flexibility	γ_6	-7.013	5.908	-20.907	-5.499	0.410
	Membership flexibility	γ_7	4.453*	1.716	1.514	4.350	7.985
Other control variables	Uncertainty	γ_8	2.990*	1.602	0.300	2.851	6.466
	Hegemony	γ_9	-12.337*	7.088	-29.073	-11.447	-2.028
	Group size	γ_{10}	0.514	0.473	-0.380	0.506	1.473
	Public goods	γ_{11}	-1.289	1.483	-4.273	-1.251	1.490
	Regime characteristics	γ_{12}	1.862	1.360	-0.524	1.756	4.763

Source: Author.

*Note: * indicates that zero is not included in the 95% credible interval.*

The meaning of Mean and SD in the table reflects the posterior mean and the posterior standard deviation as in the previous table about the environmental effectiveness model. As mentioned in the Section 5.5.1, 10,000 more iterations are discarded than in the environmental effectiveness model to gain stable shape of the traces. The result in the table is estimated from samples after the convergence.

The estimation result based on the Bayesian approach show that the obligation variable from the legalization elements and the flexibility of regime body, decision-making, and membership are statistically significant with positive signs. Moreover, with regard to the control variables, the uncertainty and hegemony variables show statistically significant effects with different signs. Accordingly, in the analysis with the economic effectiveness as the dependent variable, only the agenda flexibility, hegemony, and public goods variables have negative signs.

First, even though all the variables related to the legalization elements of IEAs have positive signs, only the obligation variable became statistically significant in the results of the full model. The obligation variable is determined by “whether it is legally binding on the members, or whether it has the character of soft law” (Breitmeier et al., 2006, p. 81) and the valuable takes 1 if a certain IEA is in manner of a hard law in this analysis. This result suggests that a significant improvement in economic performance can be confirmed with stronger legally regulated IEAs, The mean of the posterior is relatively high, compared with other variables, indicating that if an IEA is compelled by law, a positive effect on economic performance is observed. Thus, Hypothesis 1-2, which assumes that legalization mechanisms are likely to have a negative impact on economic performance of member countries, is rejected. On the other hand, precision and delegation elements of legalization have an indistinctive effect on the economy.

This result is contrary to expectation, since a negative effect on the economy is expected because of stricter regulation for preventing decline in environment. There is a possibility that more developed countries that are able to mitigate the economic burden are likely to participate in more legally binding IEAs. Otherwise, in a more positive perspective, it is also conjectured that IEAs with stricter obligation could stimulate investments or support the development of technologies to reduce pollutants effectively, and this process triggers a kind of innovation that mitigates economic costs. As emphasized in earlier chapters, this supposition is in line with the Porter Hypothesis, which argues that IEAs improve both environmental and economic performance through enhancing innovation and, thus, greater economic efficiency (Esty & Porter, 2001; Lanoie et al., 2011; Porter & van der Linde, 1995).

As for the findings related to flexibility factors of IEAs, the three flexibility mechanisms, with the exception of the agenda flexibility, are likely to be more effective on economic growth. The agenda flexibility variable shows an opposite influence on the economic effectiveness, but the mean value is not statistically robust, as the estimated 95%

posterior distribution has zero. The regime body flexibility in this chapter is defined as the situation in which there is a regular decision entity and a capability to regime behaviors with a valid influence. Therefore, it is found that IEAs that have a capacity to modify the decision-making process flexibly with a regular decision entity have a positive and significant effect on economic accomplishment.

Next, economic effectiveness also positively depends on the flexibility of decision-making, which reflects more flexible decision-making process for arriving at decisions, with a high mean of the estimated posterior distribution. In other words, a more flexible decision-making process leads to economic development—about 48.192 more possibility of improvement increasing is evaluated in detail. In addition, the result of the membership flexibility variable also reveals that substantial decision-making authority toward membership is connected to the economic effectiveness of IEAs. As a result, Hypothesis 2-2, *"flexibility mechanisms are likely to have a positive impact on the economic performance of member countries"*, is accepted, since the empirical evidences about three elements of flexibility mechanism are observed as positive and statistically significant.

The estimation results related to the control variables, the uncertainty and hegemony variables, are determined as regime elements that have a significant effect on economic performance. In the case of the uncertainty variable that reflects the degree of understanding of the environment problem intended by IEAs, a positive mean value of the posterior parameter is identified, contrary to the analysis of the determinants affecting the environmental effectiveness of IEAs. Interestingly, this can be explained by the consideration that an IEA that reach consensus, causes and consequences of environmental problems has a contradictory effect on its effectiveness. Moreover, the hegemony variable indicating the distribution of the power of IEAs has significant results with a negative sign. Therefore, the adverse effect of power distribution of IEAs among participating countries on the economic effectiveness of IEAs is confirmed in this analysis. In this chapter, the hegemony variable takes the value 1 if uneven power distribution is observed. Therefore, this result shows that if a certain country is involved in IEA formation with issue-specific power, the economic effectiveness of IEAs tends to be decreased.

Finally, the influences of other control variables—the public goods, group size, and characteristics of IEAs—on the effectiveness of IEAs are not robust, as in the analysis related to the environmental effectiveness. Therefore, it can be said that the effect of those regime elements on pollutant reduction and economic growth is not that large. In addition, in general, with regard to the industrial pollution type, IEAs can hinder industrial growth more than the nature conservation type, since more specific regulations are imposed. For example, the protocols of LRTAP set out in Chapter 3, which is a representative industrial pollution type IEAs, clarify detailed information for reducing specific pollutants and set emission reduction goals, while most nature conservation types, such as the Biodiversity Regime, are not detailed.

Nevertheless, the result of the full model shows that there are no significant differences between industrial pollution type and nature conservation type.

In summary, the assumption about the effect of legalization on the economic effectiveness of IEAs is dismissed in this analysis; that is, Hypothesis 1-2 is rejected. The result of the obligation variable indicates that strict regulation for preventing decline in the environment has a positive effect on economic performance. However, Hypothesis 2-2 is accepted, with empirical evidence. The results about flexibility mechanism depict that flexibility in the characteristic of the regime body, decision-making, and membership positively correlates with economic growth of member countries.

Note that the result about which regime elements affect the economic effectiveness of IEAs is very suggestive, since the quantitative analysis on this aspect is conducted for the first time in this thesis. Therefore, the study, confirming the phenomenon of the influence of IEAs on not only pollutant reductions but also economic growth, is meaningful. With regard to the hypotheses about the economic effectiveness, it is true that a negative effect of more legalized IEAs is expected. However, the empirical results show some unexpected and rather positive effects on economic performance. Moreover, it is noteworthy that most regime elements, except the uncertainty variable, show no contrary effect of regime elements among the statistically significant variables, even though only the decision-making flexibility has a positive influence on both environmental and economic performance of member nations.

These results allude to the favorable possibility of establishing IEAs to protect the environment in a way that is compatible with economic growth.

As in the empirical results from the Bayesian probit model illustrated above, the various regime elements affecting the effectiveness of IEAs, significant factors in the environmental effectiveness and the economic effectiveness are found to differ. Moreover, it is identified that a regime element, such as the degree of understanding about environmental issue of IEAs, has the opposite effect by model. In fact, the economic burden of participation in IEAs is a critical negative consideration in the ratification of IEAs, especially in developing countries. Therefore, there is a strong need to consider the overall impact on both environmental and economic performance attributable to the implementation of IEAs, even with regard to the perspective of sustainable development.

This study quantifies the economic effectiveness of IEAs and reveals the regime elements that have an effect on the environmental and economic effectiveness. Therefore, it has the potential to make a significant contribution to the formation and implementation of IEAs in the future.

5.6 Chapter Conclusions

In the investigation of previous chapters with LRTAP and the Kyoto Protocol, it was observed that there are significant differences in the effectiveness of IEAs on environmental and economic performance; thus factors affecting the effectiveness are perceived to diverge in each IEA. From the empirical evidence on the various pollutants in Chapter 3 and the influence of the mitigation mechanisms in Chapter 4, it is expected that the differences in the effectiveness are also derived from regime elements inherent in each IEA.

Therefore, to answer the research question of which regime elements of IEAs have a beneficial effect on the environmental and economic performance of member countries, this study performed quantitative analysis about the determinants based on the database generated by evaluating the effect of IEAs on environments and the economies of member countries. With the dependent variables about the environment and economic effectiveness of IEAs and the regime elements of IEAs as the independent variables, the analysis is subjected to investigating what regime elements represented by legalization and flexibility affect the effectiveness of each agreement. Since the database about the effectiveness and regime elements is quite limited in terms of sample size, methodologies of classic statistics are not suitable for the analysis of this chapter. Hence, the probit models with the Bayesian approach are used in the empirical analysis in the present study. Through the process of predicting the posterior distribution of parameters, it is possible to draw the influence of each regime element.

The results of this chapter reveal the statistically significant empirical evidence that is contrary to expectations in the analysis about the legalization elements. From the result that IEAs with more precise rules have a negative effect on environmental performance, Hypothesis 1-1, which assumes that legalization mechanisms are likely to have a positive impact on environmental performance of member countries, is dismissed. Moreover, against expectations, IEAs that are legally bound show a significant improvement of economic performance. As a result, Hypotheses 1-2, about the positive influence of flexibility mechanisms on environmental performance of member countries, is also rejected. On the contrary, the analysis results about flexibility mechanisms support the hypotheses. All the variables included in the credible interval of 95% are observed as positive in both the environment and economy models. Thus, the results confirm that flexibility mechanisms of IEAs are likely to have a positive impact on the environmental and economic performance of member countries. Consequently, Hypotheses 2-1 and 2-2 are accepted.

To conclude, this study has empirically confirmed the need for regime-making to improve both the economic and environmental effectiveness of, as well as the current status of, IEAs. The significant regime elements of legalization and flexibility are observed as different in the environmental and the economic analyses. To enhance participation in IEAs and improve their effectiveness, actions to mitigate the economic burden of participation in

IEAs are usually considered from the perspective of flexibility mechanisms, such as the emission trading system of the Kyoto Protocol. However, the findings suggest that policy makers of IEAs should comprehensively consider various regime elements along with the status of member countries for the construction of more effective IEAs.

It is worth noting that one of the significant and unique conclusions of this research in the IEA field is the finding that significant regime elements have an effect on not only the environmental effectiveness but also the influence on economic performance among the participating countries. Another implication of this study is that, using more appropriate methodologies (the Bayesian probit model), it is possible to gain reliable empirical evidence from small samples. However, since only a small number of IEAs were considered in the analysis of this chapter, and the database is still limited, the empirical findings are perceived as limited, thus far. Further analysis will cover a wider variety IEAs for improving the database, and apply a variety of analytical techniques, such as better targeting of the treaties.

5.7 Chapter Acknowledgment

The author wishes to express deep gratitude to Dr. Tobias Böhmelt of ETH Zurich and Dr. Ulrich H. Pilster of University of Essex, for kindly providing the data in the pursuit of the analysis of this chapter.

Appendix 5.1 Environmental Problems of Regimes

Regimes	Environmental problems
International Regulation of Whaling	Conservation of Whale Stocks Orderly Development of the Whaling Industry
Long-Range Transboundary Air Pollution	Enhancement of East-West Cooperation and Detente Transboundary Air Pollution Causing Damage to Ecosystems
Antarctic Regime	Jurisdictional Differences/Conflicts About Overlapping Claims on the Part of Claimant States Growth of Interest in Managing Exploitation of Resources in and around Antarctica Jurisdictional Differences/Conflicts Between Claimants and Major Nonclaimant States
Stratospheric Ozone Regime	Losses of Stratospheric Ozone Caused by Ozone Depleting Substances
CITES Convention	Protecting Endangered Species Maintaining a Sustainable, Legal Trade in Plants and Animals
Protection of the Rhine Against Pollution	Pollution Causing Damage to Ecosystems and Water Quality Especially in Downstream Countries
South Pacific Fisheries Forum Agency Regime	Coordination of fisheries management among the members of the SPF in order to 1) regulate tuna harvest by DWFNs and 2) maximize returns to the PICs
Baltic Sea Regime	Concern for the State of the Baltic Sea as a Very Vulnerable and Sensitive Area
Barents Sea Fisheries Regime	Over-fishing caused by strong competition over scarce fish-stocks shared in the Barents Sea region
Tropical Timber Trade Regime	Underdevelopment of a commercially viable tropical timber industry Increased evidence of significant levels of tropical deforestation and rainforest degradation in developing tropically forested countries
North Sea Regime	The protection of the marine environment of the North-East Atlantic, with emphasis on the North Sea Area
Climate Change Regime	increase of greenhouse gases in the atmosphere and inability of humans and ecosystems to adapt to the impacts of climate changes that ensue
Danube River Protection	prevention/control of pollution from, in particular, hazardous substances and nutrients by up- and downstream countries into the aquatic environment of the Danube River Basin and into the Black Sea

Desertification Regime	Land degradation in arid, semi-arid and dry subhumid areas resulting from various factors, including climatic variations and human activities
Ramsar Regime	Wetland reclamation, destruction and degradation and the impact of this habitat loss on the conservation status of wild birds Wetlands as components in human development, conservation of biodiversity and water issues
Great Lakes Management Regime	Managing a Variety of Human Activities Affecting the Great Lakes Themselves and the Regional Ecosystem of which the Lakes are the Core
Hazardous Waste Regime	exports and imports of hazardous waste from industrialised to developing countries
Oil Pollution Regime	Coastal Oil Pollution and Sea-Bird Deaths due to Oil Pollution from Intentional Discharges and Accidental Oil Pollution
IATTC Regime	To conduct scientific studies on, and make management and conservation recommendations for, tuna, baitfishes and other kinds of fish taken by tuna fishing vessels in the Eastern Pacific Ocean To conduct scientific studies on, and make recommendations for the conservation of dolphins captured by vessels fishing tuna in the Eastern Pacific Ocean
London Convention Regime	To prevent pollution by dumping of waste and other matter creating hazards to human health, harming living resources/marine life, damaging amenities or interfering with other legitimate uses of seas
ICCAT Regime	To ensure effective international conservation and management of tunas and tuna-like species which migrate extensively in the Atlantic ocean including the adjacent seas
Biodiversity Regime	Conservation of biodiversity, sustainable use of its components, and fair sharing of benefits arising out of the use of genetic resources
Regime for Protection of the Black Sea	Ongoing degradation to the ecosystem of the Black Sea and unsustainable use of its natural resources

Source: Breitmeier et al. (2006).

Appendix 5.2 Analyzed IEAs

Regimes	IEAs
International Regulation of Whaling	Whaling Regime 1946–1982 A
	Whaling Regime 1946–1982 B
	Whaling Regime 1982–1998 A
	Whaling Regime 1982–1998 B
Long-Range Transboundary Air Pollution	LRTAP Convention 1979–1982 A
	LRTAP Convention 1979–1982 B
	LRTAP Convention 1982– 1998
	First Sulphur Protocol 1985–1998
	NO_X Protocol 1988–1998
	VOCs Protocol 1991–1998
	Second Sulphur Protocol 1994–1998
Antarctic Regime	Antarctic Treaty 1959–1980 A
	Antarctic Treaty 1959–1980 B
	Antarctic Treaty 1959–1980 C
	Antarctic Treaty 1980s A
	Antarctic Treaty 1980s B
	Antarctic Treaty 1980s C
	Antarctic Treaty 1989/91–1998 A
	Antarctic Treaty 1989/91–1998 B
	Antarctic Treaty 1989/91–1998 C
	Conservation of Flora and Fauna 1964–1980 A
	Conservation of Flora and Fauna 1964–1980 B
	Conservation of Flora and Fauna 1964–1980 C
	Conservation of Flora and Fauna 1980s A
	Conservation of Flora and Fauna 1980s B
	Conservation of Flora and Fauna 1980s C
	Conservation of Flora and Fauna 1989/91–1998 A
	Conservation of Flora and Fauna 1989/91–1998 B
	Conservation of Flora and Fauna 1989/91–1998 C
	Conservation of Seals 1972–1980 A
	Conservation of Seals 1972–1980 B
	Conservation of Seals 1972–1980 C
	Conservation of Seals 1980s A
	Conservation of Seals 1980s B

	Conservation of Seals 1980s C
	Conservation of Seals 1989/91–1998 A
	Conservation of Seals 1989/91–1998 B
	Conservation of Seals 1989/91–1998 C
	CCAMLR 1980s A
	CCAMLR 1980s B
	CCAMLR 1980s C
	CCAMLR 1989/91–1998 A
	CCAMLR 1989/91–1998 B
	CCAMLR 1989/91–1998 C
	Protocol on Environmental Protection 1991–1998 A
	Protocol on Environmental Protection 1991–1998 B
	Protocol on Environmental Protection 1991–1998 C
Stratospheric Ozone Regime	Vienna Convention 1985–1990 A
	Vienna Convention 1990–1998 B
	Montreal Protocol 1987–1990 A
	Montreal Protocol 1990–1998 B
	London Amendment 1990–1998
	Copenhagen Amendment 1992–1998
	Multilateral Fund 1990–1998
CITES Convention	CITES Convention 1973–1989 A
	CITES Convention 1973–1989 B
	CITES Convention 1989–1998 A
	CITES Convention 1989–1998 B
	TRAFFIC-Network on Monitoring an Compliance 78–89A
	TRAFFIC-Network on Monitoring an Compliance 78–89B
	TRAFFIC-Network on Monitoring an Compliance 89–98A
	TRAFFIC-Network on Monitoring an Compliance 89–98B
Protection of the Rhine Against Pollution	Chloride Pollution Convention 1976–1998
	Chemical Pollution Convention 1976–1998
	Ecosystem/Salmon (RAP) 1987–1998
South Pacific Fisheries Forum Agency Regime	General Management of Fisheries in the South Pacific Region 1979–1982
	General Management of Fisheries in the South Pacific Region 1982–95/ 97
	General Management of Fisheries in the South Pacific Region 95/97–98
	Compliance of Fisheries Management 79–82
	Compliance of Fisheries Management 82–95/97
	Compliance of fisheries management 95/97– 98

Baltic Sea Regime	Environment Protection Principles 1974–1992 Environment Protection Principles 1992–1998 Principles of Co-operation 1974–1992 Principles of Co-operation 1992–1998 Regulations all Sources of Marine Pollution74–92 Regulations all Sources of Marine Pollution 1992–1998 Nature Conservation 1992–1998
Barents Sea Fisheries Regime	Norwegian-Russian Cooperation on Fisheries in the Barents Sea Region 1975–1998
Tropical Timber Trade Regime	International Tropic Timber 83–98 A International Tropic Timber 83–98 B
North Sea Regime	OSCOM/PARCOM 1972/74–1984 OSCOM/PARCOM/OSPAR 1984/92–1998 North Sea Conferences 1984–1998
Climate Change Regime	UNFCCC 1992–1997 UNFCCC 1997–1998 UNFCCC Financial Mechanism 1992–1997 UNFCCC Financial Mechanism 1997–1998 Kyoto Protocol to UNFCCC 1997–1998
Danube River Protection	Danube River Protection 1985–1991 Danube River Protection 1991–1994 Danube River Protection 1994–1998
Desertification Regime	United Nations Convention to Combat Desertification 1994–1998
Ramsar Regime	Ramsar Convention 1971–1987 Ramsar Convention 1987–1998
Great Lakes Management Regime	Great Lakes Water Quality 1972–1978 Great Lakes Water Quality 1978–1998 Great Lakes Water Quantity 1972–1978 Great Lakes Water Quantity 1978–1998 Great Lakes Ecosystem Management 1978–1998
Hazardous Waste Regime	Basel Convention 1989–1995 Basel Convention 1995–1998 Amendment to the Basel Convention 1995–1998 OECD/EU/Lome IV-regulations 1989–1995 OECD/EU/Lome IV-regulations 1995–1998 Bamako Convention 1991–1995 Bamako/Waigani Conventions 1995–1998

Oil Pollution Regime	Oilpol 1954–1978 MARPOL 1973/78–1998 Regional Memoranda of Understanding 1982–1998
IATTC Regime	Conservation and Management of Tunas and Tuna-Like Fishes 1949–1976 Conservation and Management of Tunas and Tuna-Like Fishes 1976–1998 Conservation and Management of Dolphins 1976–1998
London Convention Regime	Wastes and Substances the Dumping of which is Prohibited 1972–1991 Wastes and Substances the Dumping of which is Prohibited 1991–1998 Wastes and Substances which, in Principle, may be Dumped 1972–1991 Wastes and Substances which, in Principle, may be Dumped 1991–1998 Regulation of Incineration at Sea 1978–1991 Regulation of Incineration at Sea 1991–1998
ICCAT Regime	ICCAT Convention 1966–1998
Biodiversity Regime	Convention on Biological Diversity 1992–1998
Regime for Protection of the Black Sea	Bucharest Convention and Protocols for Protection of the Black Sea against Pollution 1992–1998 Black Sea Strategic Action Plan 1996–1998

Source: Breitmeier et al. (2006).

Note: IEAs belong to 23 regimes have been sorted by period-specific and different purposes and parts of regimes are examined by several experts.

Appendix 5.3 Results of the Environmental Effectiveness Models per Category

Categories	**Variables**	$\boldsymbol{\beta}$	**Legalization**		**Flexibility**		**Full**	
			Mean	SD	Mean	SD	Mean	SD
Intercept		β_0	0.741	0.519	-0.429	0.516	-0.500	0.936
Legalization	Obligation	β_1	-0.163	0.346			0.247	0.547
	Rule precision	β_2	-1.579*	0.359			-3.396*	0.831
	Secretariat independence	β_3	-0.294	0.402			-0.877	0.649
Flexibility	Regime body flexibility	β_4			0.798*	0.374	0.231	0.662
	Decision-making flexibility	β_5			-0.269	0.743	2.927*	1.274
	Agenda flexibility	β_6			0.121	0.236	0.667	0.407
	Membership flexibility	β_7			0.236	0.361	-0.081	0.523
Other control variables	Uncertainty	β_8	-1.718*	0.489	-1.361*	0.422	-2.011*	0.583
	Hegemony	β_9	0.381	0.429	0.121	0.452	-0.576	0.532
	Group size	β_{10}	-0.035	0.140	-0.022	0.154	0.377	0.257
	Public goods	β_{11}	0.034	0.340	0.084	0.381	0.521	0.673
	Regime characteristics	β_{12}	0.042	0.347	-0.116	0.400	-0.190	0.607

Source: Author.

*Note 1: * indicates that zero is not included in the 95% credible interval.*

Appendix 5.4 Results of the Economic Effectiveness Models per Category

Categories	Variables	γ	Legalization		Flexibility		Full	
			Mean	SD	Mean	SD	Mean	SD
Intercept		γ_0	-2.432*	1.158	-6.041*	1.651	-78.182*	15.443
Legalization	Obligation	γ_1	1.417	0.846			68.042*	14.923
	Rule precision	γ_2	-0.563	0.521			2.544	1.494
	Secretariat independence	γ_3	2.006*	0.611			1.770	1.329
Flexibility	Regime body flexibility	γ_4			3.129*	1.057	5.487*	2.395
	Decision-making flexibility	γ_5			4.774*	1.509	48.192*	17.277
	Agenda flexibility	γ_6			0.800	0.613	-7.013	5.908
	Membership flexibility	γ_7			4.071*	0.943	4.453*	1.716
Other control variables	Uncertainty	γ_8	0.297	0.572	0.809	0.711	2.990*	1.602
	Hegemony	γ_9	-0.681	0.609	-2.098*	1.155	-12.337*	7.088
	Group size	γ_{10}	-0.114	0.237	-0.162	0.306	0.514	0.473
	Public goods	γ_{11}	0.212	0.452	-1.209	0.789	-1.289	1.483
	Regime characteristics	γ_{12}	0.126	0.449	3.064*	0.905	1.862	1.360

Source: Author.

*Note: * indicates that zero is not included in the 95% credible interval.*

CHAPTER 6

Conclusion

This thesis evaluates the effect of IEAs on environmental and economic performance from the perspective of sustainable development. The theoretical framework underlying the effectiveness of IEAs is illustrated by elaborate quantitative methodologies based on impact evaluation to investigate the consequences of IEAs on environmental and economic performance of member countries concurrently with identify the possibility of establishing IEAs to simultaneously enable economic development to proceed in a sustainable manner while addressing the adverse effects on economy. The environmental and economic effectiveness of IEAs is empirically investigated with the four protocols of LRTAP and the Kyoto Protocol. From the empirical evidence from these two cases, it is revealed that there are significant differences in emission reduction and economic burden among various IEAs; nevertheless, it is found that the beneficial influence of market based mechanisms with the principle of “common but differentiated responsibilities” is not enough to mitigate the economic burden.

Based on these results, the analysis about the impact of regime elements that is inherent in each IEA is conducted. Consequently, the reliable empirical evidence reflects that some significant regime elements of legalization and flexibility are observed as different in the environmental and the economic analyses. The empirical findings of this thesis contribute to realizing sustainable global IEAs that simultaneously reduce pollutants while promoting economic performance of member countries. This final chapter is concluded with the summary of the key finding and implications of each main chapter.

6.1 Summary of Main Findings and Contributions

6.1.1 The Effectiveness of LRTAP. In response to a growing need to cope with environmental degradations, especially in transnational environmental issues, the international community realizes keenly the necessity of mutual cooperation for resolving environmental problems. Scholars have devoted their efforts to assessing the effectiveness of IEAs accurately in accordance with a rapid rise in the number of IEAs. Nevertheless, scholars who are skeptical about an endemic characteristic of international policy cast a great deal of doubt on the practical effectiveness of IEAs. To determine empirical evidence on the effectiveness of IEAs, the protocols of the LRTAP regime are investigated in various quantitative methodologies, since the numerical environmental performance data is easier to get, and the history is also relatively longer than other IEAs. The LRTAP regime, which is under the notion of common responsibility imposing emission reduction obligations among member nations, is known as a representative successful IEA. Nevertheless, empirical results of previous studies are rather inconclusive due to the lack of sufficient research period and difficulties to gain data sets of diverse pollutants.

In this context, the first and second chapters try to attain evidence to answer the first sub-question: *How do IEAs concerning different pollutants affect emission reduction in consideration of the emission reduction trends of participants and non-participants?* And the second sub-question: *How much economic burden is placed on member countries by participating in IEAs? Is there any possibility to simultaneously improve economic performance while reducing pollutants of member countries?* The first main chapter, Chapter 3, seeks to ascertain the effectiveness of IEAs by evaluating the effect of the LRTAP regime on environmental and economic performance with more extensive research objects and advanced statistical technique. In this chapter, the Helsinki protocol, the Oslo Protocols (SO_X emissions), the Sofia Protocol (NO_X emissions), and the Geneva Protocol (NMVOC emissions) of LRTAP were selected for the quantitative analysis in the consideration of satisfy enough research periods and data availability for applying the quantitative method. The panel data of each protocol are produced based on the 50 parties (except the EU as a whole) of the 1979 Geneva Convention on LRTAP from 1970 to 2005.

In terms of the methods, the impact evaluation technique combining the PSM and DID methods is applied. Therefore, based on the propensity score, which is calculated by the observed characteristics GDP and population of nations, participants and non-participants a substantial region of common support is matched by the DID matching estimator, which can be applied in the panel data. After the matching process, only selected matched countries are used for the DID analysis, setting the adoption year and the goal years of each protocol as the base year and the target year, respectively. Finally, the panel fixed-effect model is conducted in both the environmental and the economic effectiveness models to estimate the effect of each protocol on emission reduction and economic growth.

The analysis about the effectiveness of LRTAP in Chapter 3 is successful in verifying the effectiveness of LRTAP with theoretical debates. Table 6.1 presents the empirical results of the effectiveness of LRTAP both in the previous studies and the present thesis. In the major quantitative analysis, the results of the Helsinki and Sofia Protocols are still controversial; moreover, the analyses on other LRTAP protocols or the economic aspect are hard to find. The results of the elaborate quantitative analysis provide empirical evidence of a restrictive positive effect of the protocols of the LRTAP regime. Only the results of the Sofia Protocol are statistically significant and identified as having a positive effect at the 5% level on both environmental and economic performance, while the results of other protocols have no statistically significant effect by participation of protocols. In a sustainable point of view, the Sofia Protocol reflects the possibility to simultaneously improve economic performance while reducing pollutants of member countries.

Table 6.1 ***The Effectiveness of LRTAP***

LRTAP		Environment		Economy	
		Previous studies	**Analysis result**	**Previous studies**	**Analysis result**
SO_X	**Helsinki**	+ / ?	Statistically insignificant	No relevant analysis	Statistically insignificant
	Oslo	+	Statistically insignificant	No relevant analysis	Statistically insignificant
NO_X	**Sofia**	+ / ?	+	No relevant analysis	+
NMVOC	**Geneva**	No relevant analysis	Statistically insignificant	No relevant analysis	Statistically insignificant

Source: Author.

Note: "+" indicates a positive effect on the environment and economy, "?" means controversial results are observed in the previous studies.

The contribution of this study is elaborated in three aspects as follows. First, this analysis covers broad samples and research periods differ from previous studies that focus on certain pollutants, such as SO_X and NO_X; thus it is possible to deepen the understanding of the effectiveness of the LRTAP regime. Most previous quantitative studies on the effectiveness of LRTAP are concentrated on the Helsinki and Sofia Protocols, which aim at prevention of SO_X and NO_X emissions. To compensate for the limited research result of previous studies, the Geneva Protocol about NMVOC and the Oslo Protocol are included in this analysis. Moreover, the economic burden of member countries is also considered in this thesis. In the results of the economic effectiveness model, no negative effect on the economic performance of participating in the protocol is found. Rather, the result of the Sofia Protocol reveals a positive effect both on the environments and economies of member countries. This comprehensive analysis adds an important quota to widen the understanding of the consequence of the LRTAP protocols from the perspective of sustainable development.

Second, this study achieves methodological improvements for covering the "proper" research periods. This thesis adopts the impact evaluation technique combining the PSM and DID methods to consider the counterfactual situation of participating in IEAs, controlling the selection bias and the problem of unobserved heterogeneity that are pointed out as difficulties in assessing the effectiveness of IEAs by several scholars. In fact, recent studies that analyze the effectiveness of IEAs in the consideration of the emission reduction trends of participants and non-participants with advanced statistical methods, such as the DID model, show different results from studies of the early stages of IEAs. With advanced statistical methods and data, it is possible to extract the net effectiveness of the protocol without the influence of external factors, such as emission trends or other differences in socioeconomic conditions. This study plays a leading role in applying the impact evaluation combining the PSM and DID methods in the field of IEAs study, since most previous studies have applied only the DID method in the analysis of the effectiveness of the protocols of LRTAP. Moreover, relatively long research periods are included in the analysis. Therefore, it is perceived that more reliable and precise empirical evidence discerns the effect of the LRTAP regime more accurately in the present study.

Finally, several significant implications are explored from the empirical evidence. The first implication is that the characteristics of diverse targeted contaminants should be considered in the process of establishing, implementing and evaluating the effectiveness of IEAs. The effectiveness of IEAs is usually evaluated by the characteristics of the institution itself not by the environmental problem targeted by IEAs. However, as the empirical results reflect, the effectiveness of IEAs can differ by IEAs with different environmental issues. Furthermore, the results of the economic effectiveness show the similar tendency. One of the reasons is that the required cost and technologies and the impact on social and economic situation are not equivalent among environmental problems. Thus, it is required to consider the characteristic and differences in pollutants in order to enhance the effectiveness of IEAs both on economic and environmental performance.

The second implication is the causality between the timing of participating in IEAs and the effectiveness. The results of the environmental effectiveness show the possibility that the effectiveness of IEAs can be influenced by the degree of development of technologies for emission reductions. The coefficients of the regime participation variable of each protocol have negative signs; only the result of the Sofia Protocol is statistically significant. In other words, even though the decreases of emissions overall is observed, there are no significant differences between participants and non-participants. In the case of NMVOC, there may be a longer-term perspective may be required for effective analysis. However, the fact that only the protocol for NO_X has a positive effect on improving environmental performance is suggestive evidence. From the literature reviews, the tendency among latent member countries to participant more actively in nations with capability to reduce emissions or forming the consensus of a need for reducing emissions prior to establishing the IEA can be one of the reasons.

Moreover, it is convinced that a positive external ripple effect of IEAs on non-participant countries, such as receiving impetus from sharing technologies related with preventing environmental pollution and scientific information between nations, is a possible scenario for the SO_X-related IEAs. Since desulfurization facilities had been developed before the IEA, it is shown that technology spillovers by advanced countries make non-participants attain SO_X emission reduction without IEAs. Hence, the timing of establishing IEAs deserves the fullest consideration to improve the effect of IEAs on reduction of pollution (i.e., such that they are not rendered redundant by such developments).

To be sure, this implication is mainly focused on the problem solving point of view. If the meaning of the effectiveness of IEAs is extended into changing the behavior of states and other actors or cost efficiency, the causality between the timing of participating in IEAs and the effectiveness can vary significantly. Even though there is no significant emission reduction by participating in IEAs, the positive effects of elevating awareness of the environmental problem, diffusion of technologies and scientific information, generating monitoring systems or data cannot be overlooked.

6.1.2 The Effectiveness of the Kyoto Protocol. The Kyoto Protocol is one of the most influential IEAs with respect to the reduction of GHG emissions as it considers national differences in initial emissions, wealth, and socioeconomic capacity under the notion of "common but differentiated responsibilities". Therefore, this protocol perceives that developed countries are mainly responsible for the high levels of GHG emissions so far; thus, internationally binding emission reduction goals were set that imposed a heavier burden on Annex I Parties. However, to mitigate the burden by emission reductions and meet emission reduction targets in a cost-effective way, several market-based mechanisms have been offered: International Emissions Trading, CDM, and JI. As a result, it is expected that the Kyoto Protocol has the possibility of applying the Porter Hypothesis to IEAs, which supports the assumption that a well-made environmental policy improves environmental performance simultaneously with the mitigation of adverse economic effect through enhancing innovation and, thus, leading to greater economic efficiency.

In this regard, two hypotheses with an optimistic viewpoint on emission reduction and economic improvement are posited in Chapter 4. On the basis of literature reviews, the first hypothesis, which is about the effect of the protocol on the CO_2 emission reductions, assumes that participating in Annex I of the Kyoto Protocol has a positive effect on a reduction of CO_2 emissions. Therefore, the first hypothesis is as follows: *Participating in Annex I of the Kyoto Protocol has a positive effect on the* CO_2 *emission reduction*. With regard to the economic influence of the protocol, there are empirical studies that argue that participating in the Kyoto Protocol causes inefficiency in economy of member countries due to imposed reduction obligations. However, this study focuses on the potential for the applicability of the Porter Hypothesis into the Kyoto Protocol, which is one of the most representative flexible international environmental policies with inherent market-based mechanisms. In this context, it is supposed that the Kyoto Protocol encourages decreasing the negative effects on economic growth. As a result, the second hypothesis is posited: *The effect of the Kyoto Protocol on the economic performance for Annex I Parties will not be negative*.

To test these hypotheses, the impact evaluation technique combining the PSM and DID methods is applied in the analyses of the environmental and economic effectiveness of the Kyoto Protocol from the time of its adoption and entry into force, to its target year. The matched samples based on the propensity score with GDP, population, and CO_2 emissions are estimated by the environmental effectiveness model and the economic effectiveness model, which is derived from the Cobb–Douglas GDP function. Moreover, additional analysis of the relationship between the IEAs participation and R&D is added to examine the practicality of the Porter Hypothesis in the Kyoto Protocol in great detail. In addition, IV method with 2SLS estimator is adopted for estimating the environmental effectiveness model, since it is necessity to solve the endogeneity problem of the GDP variable in the environmental equation. Through those elaborate designing quantitative analysis process; it is possible to gain more robust empirical evidences. Moreover, based on the results of the fixed-effect regression procedure using the impact evaluation combining the PSM and DID methods, predicted estimations of the real and hypothetical IEA effect on CO_2 emissions and GDP growth are calculated.

The main findings concerning the effectiveness of the Kyoto Protocol are shown in Table 6.2. The empirical findings of this study partly differ from expectations. While the results provide a robust empirical support for the first hypothesis about the effect on emission reductions, the results about the economic burden of Annex I countries do not support the second hypothesis. In other words, the Kyoto Protocol has a significant positive effect on CO_2 emissions decline, but does not seem to help improve economic growth. Rather, economic performance is impeded by participating in Annex I, and this empirical evidence coincides with the outcomes of the previous empirical analyses.

Table 6.2 ***The Effectiveness of the Kyoto Protocol***

The Kyoto Protocol	Environment		Economy	
	Hypotheses	Analysis result	Hypotheses	Analysis result
	+	+	+	-

Source: Author.

Note: "+" indicates a positive effect; on the contrary, "-" indicates a negative effect on the environment and economy.

The additional analysis about the effect of participating in Annex I on the R&D expenditure also reflects a negative effect in the line with the result of the economic effectiveness model. Accordingly, it is revealed that even though the Kyoto Protocol adopted the market-based mechanisms for mitigating economic costs, it is currently difficult to improve both environmental and economic performance. Through comparing the real and hypothetic prediction values among Annex I countries, it is identified that the emission reduction effect is much greater than the hindrance of economic growth.

The empirical findings of the analyses about the effectiveness of the Kyoto Protocol contribute in various respects. First, this analysis about the effectiveness of the Kyoto Protocol in consideration of the Porter Hypothesis is being attempted for the first time. The quantitative research about the Kyoto Protocol has thus far been conducted mainly on the environmental effect on member countries. Some previous studies have tried to discern the economic burden in the aspect of cost efficiency; however, it is difficult to find the analysis on the economic effectiveness in parallel with the environmental effectiveness; thus, implications for sustainable development have remained obscure. This study expands existing literature by testing the effect of the Kyoto Protocol on both economic and environmental performance. Even though the Porter Hypothesis does not suggest a valid model for identifying the economic effectiveness of the Kyoto Protocol in this analysis, this novel endeavor represents a significant contribution to the sustainable development point of view, since it presents a new perspective for understanding IEAs, refining how international environmental policy can contribute to economic performance. Note that more long-term follow-up analysis is required to confirm whether the Porter Hypothesis is feasible in the context of IEAs.

Second, a deeper understanding about market-based mechanisms is attained from the empirical evidence of the economic effectiveness based on theoretical considerations. This thesis regards the flexible mechanisms inherent in market-based mechanisms as a principal cause of an applicability of the Porter Hypothesis. However, some installations, such as the CDM mechanism, are ill-suited to stimulating the innovation process, since they are allowed to implement project-based emission reductions in developing countries with comparatively lower degree of technologies and small amount of investigations. In this unsuspected aspect at least, the Porter Hypothesis, which assumes well-made environmental regulations encourage innovation and eventually achieve cost savings, is problematic for explaining the economic effectiveness operations of the Kyoto Protocol. Consequently, it is suggested that more comprehensive consideration about the influence such flexible mechanisms have on member countries' socioeconomic conditions is also important when discussing the effect of IEAs. Moreover, it is noteworthy that even though most quantitative studies on the effectiveness of IEAs usually evaluate the effectiveness by the degree of change in emission reductions of each participant, it is necessary to consider global effectiveness and domestic effectiveness separately.

Finally, this study is a starting point for multifaceted analyses, such as a comparative study on each commitment period, or an investigation of non-participating countries, such as China, the United States of America, and India. Since a prime reason for evading participation in IEAs is an expected negative effect on economic growth, such as costs for pollution control policy or investment in environmental facilities, it is desirable to provide empirical evidence that identifies the real economic effectiveness instead of vague concerns about the negative effect on economic growth. In this context, this study blazes a trail to further research about the analysis, focusing on other countries, with broader data with longer periods including the first commitment periods.

6.1.3 The Regime Elements Affecting the Effectiveness of IEAs. The last chapter of this thesis complements and generalizes the empirical results from previous chapters with the database of various IEAs. The quantitative analyses in the previous chapters with two representative IEAs revealed the significant differences in the effect of emission reduction and economic burden among IEAs. More specifically, Chapter 3 investigated the effectiveness of the protocols of LRTAP with different pollutants, finding that only the Sofia Protocol, which is aimed at reducing NO_X emissions, has a statistically significant effect on both environmental and economic performance. These results, on the basis of the elaborate impact evaluation methodologies, are supported by several previous studies providing theoretical and empirical evidence about the possibility that an IEA with a certain pollutant shows a significant effectiveness while other protocols are not robust. Moreover, Chapter 4 focuses on the Kyoto Protocol, which embeds the flexible market-based mechanisms for mitigating economic burden, to determine the adoptability of the Porter Hypothesis in IEAs. The results demonstrate that the protocol has a positive effect on CO_2 emissions decline, whereas participating in Annex I Parties has a negative effect on economic growth. Based on these results, theoretical evidence about the influence of regime elements, including the institutional factors, is driven in line with the unexpected adverse effect of market mechanisms, such as the CDM mechanism.

Even though analysis results of previous studies depict the multifaceted effectiveness of IEAs, it is necessary to examine more specifically which regime elements have an effect on the effectiveness of IEAs to define the mechanism of the effectiveness of IEAs more deeply. Therefore, unlike previous chapters, which focused on the overall effectiveness of specific IEAs, the study in Chapter 5 investigates whether flexibility and legalization elements are influential on pollutant reduction and economic growth. As a result, the last analysis is designed to answer the third research question: *Which regime elements of IEAs have a beneficial effect on the environmental and economic performance of member countries?* In order to shed light on the underlying factors influencing the validity of IEAs, this study focuses on two regime elements: legalization and flexibility. The legalization elements are defined with three components—the obligation, precision, and delegation—and a beneficial effect on environmental improvement but negative effect on economic performance are supposed given stricter regulation for preventing decline in the environment.

This chapter posits the hypotheses about legalization and flexibility on the bases of previous discussions about each element. From the discussions about legalization, it is assumed that the legalization elements of IEAs have a beneficial effect on the environment but negative effect on the economy because of hindrance of strict regulation (for preventing decline in environment) on economic growth. In the case of the flexible mechanism, it is expected a positive effect on both the environment and economy as more adjustable options are provided for participants. To put forward evidence to support the hypotheses, the IRD that contains a wide variety of information on 123 IEAs is mainly used after improving process for gaining more precise analysis result about determinants of the effective IEAs. The empirical analysis proceeds in two steps. The first step is to produce the quantitative data on the economic effectiveness of IEAs using the impact evaluation technique, since there is no numerical database about the economic effectiveness of various IEAs. Second, after completing data collection, the regime elements affecting the effectiveness of IEAs are investigated by the probit model with the Bayesian approach. The data only cover 123 IEAs; thus, the Bayesian approach is adopted, since it does not require a large sample size, unlike classical statistical methods.

The posterior distributions of each parameter by the Bayesian method provide the empirical evidence of determinants of effective IEAs. The empirical results of this study are summarized in Table 6.3. In the model of the environmental effectiveness, the rule precision variable of the legalization category and the decision-making flexibility of the flexibility category are found to be statistically significant. The results indicate that IEAs with clearer and more precise rules have a negative effect on environmental improvement, while more environmental improvement can be achieved if a given IEA has a more flexible decision-making process. Accordingly, the hypothesis that assumed legalization mechanisms are likely to have a positive effect on the environment is rejected. On the other hand, the results of the economic model show a positive effect on both legalization and flexibility categories. Specifically, more strongly legally regulated IEAs are likely to be more conducive to economic growth. Moreover, the economic effectiveness also positively depends on the flexibility of regime body, decision-making, and membership. In other words, the existence of a capacity to modify regime behavior flexibly with a regular decision entity, flexibilities of decision-making , and substantial decision-making authority toward membership are positively connected to the economic effectiveness of IEAs. As a result, the hypothesis about legalization of the economic model is contrary to expectations.

Table 6.3 ***The Regime Elements Affecting the Effectiveness of IEAs***

Regime elements	Environment		Economy	
	Hypotheses	**Analysis result**	**Hypotheses**	**Analysis result**
Legalization	+	- Rule precision	-	+ Obligation
Flexibility	+	+ Decision-making flexibility	+	+ Regime body flexibility Decision-making flexibility Membership flexibility

Source: Author.

Note: "+" indicates a positive effect; on the contrary, "-" indicates a negative effect on the environment and economy.

In addition, in the results of other control variables, only the uncertainty IEAs, which indicate the lack of consensus about the environmental issues, exert a bad effect on the environmental effectiveness, while a significant effect on increase in economic performance. On the other hand, the uneven distribution of the power among IEAs participants is negatively correlated with the negative effectiveness.

This study contributes toward not only significant findings but also contributes to the aspect of methodology of the field of IEAs. First, the analyses of Chapter 5 achieve a number of methodological improvements. Even though this analysis is based on the database from the previous studies, the empirical process involves vigorous effort to improve the established database and to find more appropriate statistical methodologies. Most of all, utilizing the

Bayesian method is especially significant in an area of research about the effectiveness of IEAs. The classical statistical methods, which are referred to as frequentist statistics, depend on large sample to gain reliable results, since they consider the statistical process as representing the infinitely repeated experiments on samples from fixed parameters. Therefore, if a sufficient sample size is not secured, the analysis result, despite a great effort, can be biased and unreliable.

On the contrary, the Bayesian methods suppose the parameters as a random variable which can be changed; thus it is possible to gain more reliable empirical findings, regardless of the small sample size. This methodological aspect is very suggestive in the area of IEAs. Since the numerical database concerning IEAs is quite limited and insufficient, scholars have pointed out that it is tricky to obtain clear results though quantitative analysis about the effectiveness of IEAs. Hence, it is usually problematic to conduct quantitative analysis applying the frequentist statistics. However, the Bayesian approach produces the posterior distribution based on combining information on samples and a prior distribution. Furthermore, advanced statistical methods, such as Gibbs sampling, can facilitate more extensive quantitative analysis. Thus, it is conceived that this study breaks fresh ground for empirical analysis in the field of IEAs.

In practical respects, the significant implications for establishing effective IEAs from the perspective of sustainable development can be deducted from the empirical finding. Even though parts of previous studies investigated the determinants of the effectiveness of IEAs, no empirical analysis has been conducted on the causality between the regime elements and economic performance of member countries. In this context, this study is uniquely designed to compare the effect of each regime element between the environmental and economic model. In this empirical framework, it is possible to discern differences and similarities about the regime elements that affect environmental improvement and economic growth. Surprisingly, the empirical results of legalization are contrary to expectations, which are overall conclusion based on previous studies in both the models. That is, it can be conceived that the practical effect of legalization elements of IEAs works differently from the theoretical discussions in reality.

On the other hand, the results of flexibility elements reflect a positive effect both in the environmental and economic models, and this is in accordance with the arguments of existing research. Based on this optimistic evidence, it is expected that the possibility to accomplish establishing IEAs to simultaneously enable economic development to proceed in a sustainable manner and environmental improvement can be embodied in flexibility mechanisms. In this regard, the explanation in company with the empirical results in the previous chapters is available. For example, although a positive effect of the market based flexible mechanisms of the Kyoto Protocol on economic performance is not identified in Chapter 4, it can be stated that various possibilities are opening up for further research with wider variety of IEAs considering the empirical evidence of this analysis. Moreover, the results reflect that other flexibility mechanisms related to the decision-making process and authority are worth consideration for enhancing both the environmental and the economic effectiveness of IEAs.

Hence, it is perceived that this study arrives at conclusions on how the existing IEAs can be improved and what regime elements have to be considered to established the IEAs for sustainable development. Note that, as this study focuses on the overall effectiveness of various IEAs, the results cannot present how each regime element is operated in IEAs. This issue is also crucial for understanding the effectiveness of IEAs. Therefore, it is necessary to undertake more specific analysis about the mechanisms of the effect of each regime element on environmental and economic performance in follow-up studies with both quantitative and qualitative approaches.

6.2 Concluding Remarks

This thesis evaluates the effectiveness of IEAs on environment and economy in the sustainable development perspective and extends the empirical evidence grasp of the current situation, suggesting a promising perspective for developing IEAs that contribute to further sustainable development. Building the conceptual connection between the effectiveness of IEAs and sustainable development based on the theoretical discussions, the first and second main chapters empirically estimate, for the first time, the effectiveness of IEAs with various pollutants. Chapter 5 (the third main chapter) attempts to investigate the relationships between the regime elements of IEAs and the effectiveness on environmental improvement and economic performance, as focusing on legalization and flexibility with the database with various IEAs, including both industrial pollution type and nature conservation type.

To evaluate the effectiveness of IEAs more systematically, advanced statistical methods are applied in all the main chapters. In particular, applying the impact evaluation combining the PSM and DID methods and the Bayesian method is a meaningful attempt. In this series of procedures for evaluating the effectiveness of IEAs, the answer is given to the research question: *Is there any possibility of establishing IEAs to simultaneously enable sustainable economic development while addressing the adverse effects on the economy? How do IEAs with the notion of common responsibility and differentiated responsibility affect the environmental and economic performance of member countries?*

The major messages of the empirical evidence of this thesis are that it empirically identified a strong need to consider various factors that can influence the effectiveness of IEAs: the diverse characteristics of pollutants targeted by each IEAs, trends of environments and economies among nations, and regime elements inherent in IEAs. This thesis also stresses the necessity of considering not only simple evaluation of the practical effectiveness by pollutant reduction but also a variety of perspectives upon the effectiveness of IEAs in the evaluating process. As the result of the protocol of LRTAP revealed, the quantitative assessment output of each IEA can vary significantly from the preciseness of statistical methodologies. Moreover, even though the empirical results concerning the effectiveness of present IEAs are observed they have limited positive effect on the economy and environment of member countries, it cannot be ignored that positive signs from the results of the Sofia Protocol and the flexible mechanisms on the possibility of IEAs that can positively influence the environment and economy simultaneously.

The empirical findings presented in this thesis also suggest a number of promising directions for further research in the field of IEAs considering a variety of factors. Even though the results of this thesis indicate that parts of IEAs have no significant effect on pollutant reduction, positive effect on other aspects, such as elevating awareness of the environmental problem, diffusion of technologies and scientific information, generating monitoring systems or data, are also significant contributions to the global sustainable development. Therefore, it is required to consider the effect of IEAs on national legislations and policies. More specifically, domestic institutional aspects—such as the development of related national laws and policies of member countries or social consciousness changes on environmental issues—can undergo various influences by the formation and implementation of international environmental policies. However, in order to conduct quantitative analysis for investigating the effectiveness of IEAs in a comprehensive manner, including those kinds of institutional factors, ingenuity is required to set up and build variable data. Conducting empirical analysis considering the multifaceted effectiveness of IEAs including such institutional factors will be an important challenge in the further IEAs research.

Going forward, the research theme of this thesis can be expanded its current realm of interest. For instance, comparative study between participants and non-participants or industrial countries and developing countries would be interesting. Even though industrial countries have the primary responsibility to mitigate pollution, developing countries also have the responsibility to achieve sustainable development coupled with adaptation and cooperation. Furthermore, case studies can be conducted on specific areas, by extension, with the private sector. This will be helpful to deepen an understanding about the mechanisms related to the Porter Hypothesis with the answer to the question of how or whether the IEAs stimulate the domestic economic units.

Overall, this thesis made significant contributions to IEAs study. First, it developed a conceptual framework concerning the effectiveness of IEAs in the sustainable development perspective and suggested the quantitative analysis models in connection with this conceptual framework. Accordingly, this thesis shows the comprehensive understanding about the effectiveness of IEAs not only in the environmental but also the economic aspect. Second, it filled gaps in the literature by providing reliable empirical evidence about the effectiveness of IEAs with expanded research objects. From the analysis of this thesis, the effectiveness of the protocols of LRTAP, which is still controversial, and that of the Kyoto Protocol are confirmed in consideration of factors that can affect to the effectiveness, such as the emission reduction trends. Third, this study opens up new possibilities of quantitative methodologies to evaluate the effectiveness of IEAs. This thesis attempts to apply advanced statistical methods to more accurately reflect the practical effect of IEAs on the environments and economies of member countries. Moreover, to overcome the problem of small sample size of the data set with various IEAs, the Bayesian approach is adopted for generating robust results in the last analysis.

Finally, the academic endeavors to evaluate the effectiveness of IEAs in this thesis have a significant implication for enhancing the effectiveness and further development of IEAs. This thesis provides an empirical basis concerning the effectiveness of IEAs; thus, not only international but also domestic policy makers can judge the environmental effectiveness and economic burden objectively based on the empirical evidence from elaborate quantitative methodologies. In other word, this thesis contributes to identifying a practical effect on pollutant reduction and mitigating indefinite concern about a negative effect on economy growth. From an international perspective, empirical evidence of this thesis can be useful to understand policy implication and limitation of existing IEAs and suggest a new direction for improving and establishing more effective IEAs in terms of sustainable development.

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