Assessment of Market Systems for CO_2 Emissions Trading As Environmental Policy Options, with Special Emphasis on Evaluation of Intertemporal Trading

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Abstract:

This paper considers the "Kyoto Protocol," a milestone in worldwide concerted efforts toward global warming abatement, from an economic viewpoint. The Kyoto Protocol set a target for reduction of collective GHG (greenhouse gas) emissions, which required industrialized countries to cut their GHG emissions so that their total emissions as of 2010 would be "5.2% below 1990 levels a year on average in the period from 2008 to 2012." To that end, the Protocol also specified GHG emissions reduction targets to be met by individual countries (areas).

According to economic theory, attainment of the collective target with maximum efficiency requires the individually specified reduction targets to be set at levels achievable by individual countries at equalized marginal reduction costs. However, gaps are inevitable between theory and actually specified targets. In terms of efficiency, it is desirable for individual countries to be able to trade such "gaps," or the differences between theoretically optimal reductions and the targets actually specified by the Kyoto Protocol, which were in fact simply a product of political compromise. The mechanism for adjustment of such gaps by allowing GHG emissions to be traded (tradable permits) is known as "emissions trading." The adjustment is made between two areas and/or between two periods (intertemporal). Regarding the former, or inter-area trading, many studies have been conducted that confirm its effectiveness in slashing the cost of reducing GHG emissions, whereas few systematic studies have been made on the latter.

Accordingly, in an attempt to verify the effects of intertemporal trading, this study first elucidated the theoretical grounds for its effectiveness by using a two-country two-period trading model (Fig. 1). Then, simulations were made by constructing an LP model (Fig. 2) extended from the aforementioned theoretical model (a ten-area six-period trading model provided with not only inter-area but also with intertemporal trading functions, which was an improvement on the "World Energy Industry Model" having an inter-area emissions trading function only). With the commitment periods punctuated every five years at 2015, 2020, 2025 and 2030, as an extension to the 2010 proposed under the Kyoto Protocol, two scenarios were prepared for running the model. One is the "Business As Usual" scenario, in which the Kyoto targets remain unchanged even from 2010 onward. The other is the "Tougher Environmental Constraint" scenario, which assumes that the Kyoto targets for stabilizing CO_2 concentrations will become tougher in the later commitment periods. A total of 36 cases were simulated by varying the conditions (parameters) that could affect banking and borrowing in each scenario.

The simulation results showed that the effect of intertemporal trading in trimming the GHG reduction cost would amount to 3 – 20% in the BUA scenario, and to 5 – 7% in the TEC scenario, thus confirming the effectiveness of intertemporal trading characterized by temporal flexibility.

Keywords: *Kyoto Protocol, Emissions Trading, GHG, Linear Program*

1. INTRODUCTION

Since the Industrial Revolution, mankind has been consuming fossil fuels (coal, oil, natural gas, etc.) in large quantities. The resultant carbon dioxide and other emissions have given rise to the greenhouse effect, which has precipitated global warming. At the beginning of the 1990s, the IPCC (Intergovernmental Panel on Climate Change) of the United Nations elucidated scientific grounds for global warming. In 1992, the international community agreed on making united efforts toward global warming abatement at the Earth Summit (United Nations Environment Development Conference in Rio de Janeiro). After the Rio summit, with the Framework Convention on Climate Change ratified by almost all governments around the world, an institutional framework of global warming abatement was established. Following this, the Third Conference of the Parties to the Framework Convention on Climate Change (COP3) held in December 1997 in Kyoto adopted the Kyoto Protocol, in which GHG emissions reduction targets were specified. Talks on how to implement the Protocol have been held at subsequent conferences from COP4 (November 1998, Buenos Aires) to COP7 (November 2001, Marrakech), after which the drafted implementation rules were approved in principle. The Kyoto Protocol, ratified by the EU in May 2002 and by Japan the following June, was expected to become effective within 2002, because its ratification by all the principal countries except the U.S. appeared likely by the end of the year. However, as of late January 2003, the combined shares in CO_2 emissions of the already ratifying parties including the EU (24.2%), Japan (8.5%), Canada (3.3%) and others (7.9%), (with total emissions of all parties liable for reductions taken as 100%) amounted to only 43.9%. This means that Russia's ratification is indispensable for satisfying the required share (over 55%) for effecting the Protocol. Since ratification benefits Russia as a seller of tradable permits, its ratification and subsequent Protocol effectuation are only a matter of time.

2. THE OBJECTIVE OF STUDY

2.1. The Target of Kyoto Protocol

The Kyoto Protocol set a reduction target to be met by the industrialized countries as a whole so that their GHG emissions as of 2010 would stand at 5.2% below 1990 levels a year on average from 2008 to 2012, and also specified the reduction targets to be met by individual countries.

2.2. The Significance of Emissions Trading

According to economic theory, meeting the collective GHG reduction target efficiently – i.e., at minimum cost – requires the individually specified reduction targets to be set at levels achievable by individual countries at an equalized marginal reduction cost. However, during international talks, no consideration was given to differences in marginal reduction costs incurred by the different countries. Instead, the individually specified targets were determined technically, with percentages lowered or raised from the 1990 records, as a result of political compromise. This was an extremely disadvantageous arrangement for Japan and other countries whose marginal reduction costs are believed to be high overall. Emissions trading is an economic mechanism that can minimize the "differences" between the theoretically optimal GHG reductions, achievable at an equalized marginal cost among individual countries and within all the Annex I parties, and the politically compromised reductions through trading of GHG emissions (tradable permits). However, the EU and its member states contended that individual countries should make greatest possible reduction efforts domestically even at high marginal cost, and that emissions trading should be a last resort and supplemental to domestic efforts, to be employed only for meeting a portion unattained by domestic efforts, if any. Their argument neglects the function that is inherent to emissions trading. Putting political goals first, they argue that emissions trading should be restricted. This is one of the critical factors behind the U.S. walkout from the Kyoto Protocol. This paper explains why restriction of emissions trading is problematic and clarifies the significance of making emissions trading restriction-free, regardless of whether it is spatial or temporal.

3. THE INTERTEMPORAL TRADING AND THE COMPROMISE DISCOUNT RATE

The "Kyoto Mechanism," an economic instrument aiming to help achieve the Kyoto targets at minimum cost, consists of three mechanisms, including emissions trading in the narrow sense (among the Annex I parties only), and represents "flexibility-rich measures" enabled by a "market mechanism"-based efficient framework. The flexibility-rich measures exist in two forms. One is "spatial (geographical) flexibility," which enables reduction cost cutting through inter-area emissions trading. The other is "temporal flexibility," which is designed to cut costs of reduction through two-point or multi-point intertemporal emissions trading. In the case of the former, many studies have been made in which its effects are demonstrated theoretically or through model-based simulations. Regarding the latter, however, few systematic studies have been made so far. The effectiveness of intertemporal trading in cutting reduction costs can be regarded as an analogy to spatial trading. In the case of intertemporal trading, the emissions reduction costs must be assessed in terms of present values. In order to express all the strings of future values consistently in present values, a time discount rate is employed. Employed here is the CDRn, the Composite Discount Rate in the "n^{th}" year consisting of four principal parameters, each having a crucial impact on intertemporal trading. The four principal parameters are the Tradable Permit Price Increase Rate (p), the Interest Rate (r), the Technology Advance Rate (t), and the GHG Sink Capacity Depleting Rate (s) which represents the rate of depleting capacity of such sinks as the oceans. CDRn is defined as follows; $CDRn = (1+p)^n(1+s)^n/(1+r)^n(1+t)^n$.

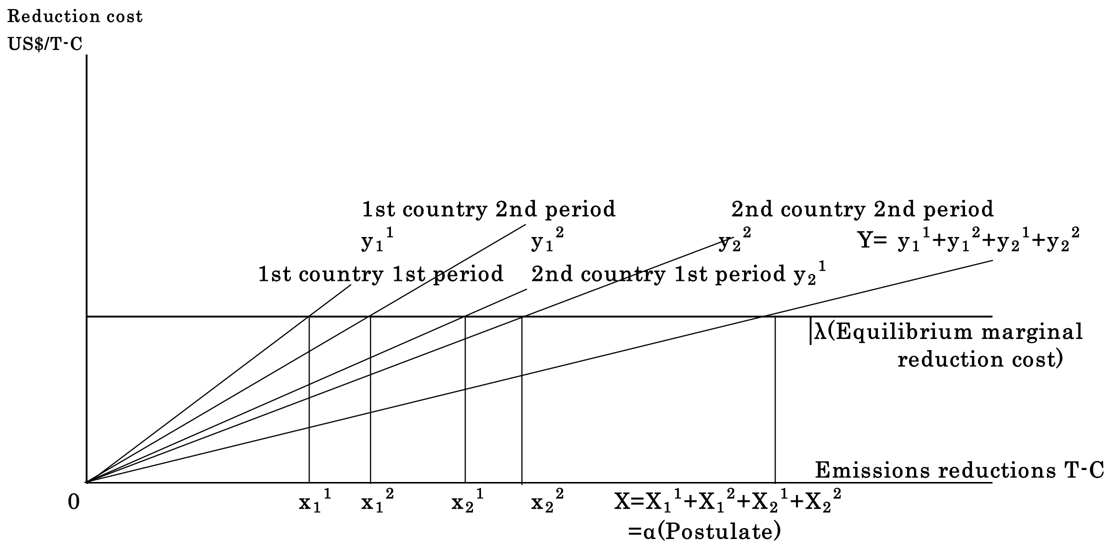

Figure 1. **Optimal Reductions with Bilateral Two-period Trading and Equilibrium Marginal Emissions Reduction Cost**

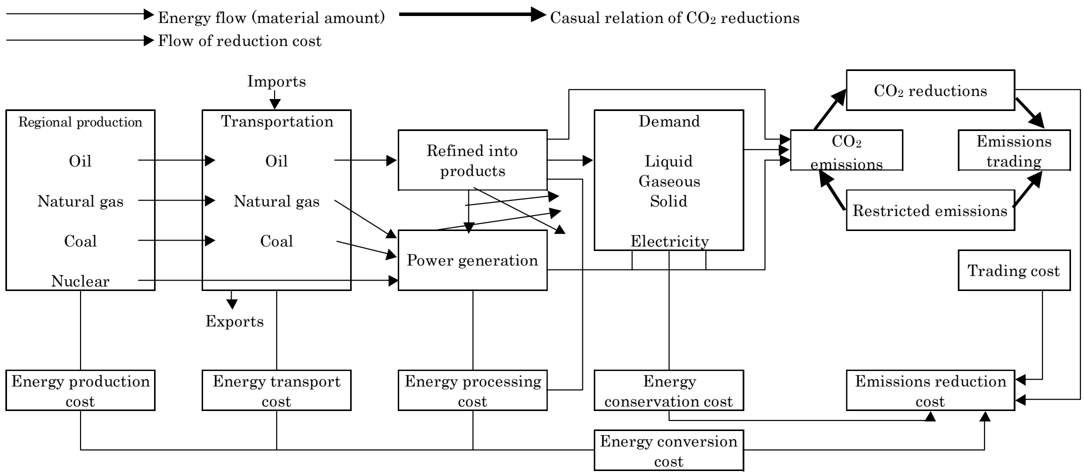

Figure 2. **Energy Flow and Flow of Emissions Reduction Cost Calculations of World Energy Industry Emissions Trading Model**

4. THE EFFECTIVENESS OF INTERTEMPORAL TRADING

4.1. Banking

Among the activities affected by CDRn is banking, a technique of intertemporal trading. Banking means saving emissions permits, or carrying them over to the next period, by reducing more emissions than targeted or by purchasing tradable permits from others during the current period. The parameters that encourage banking are the Tradable Permit Price Increase Rate (p) and the GHG Sink Capacity Depleting Rate (s). On the other hand, the Interest Rate (r) and the Technology Advance Rate (t) discourage banking. These relations are expressed with equations in use. First, when CDRn >1, banking is encouraged, which contributes to lowering the cost of emissions reduction at different points of time.

4.2. Borrowing

Borrowing is another technique of intertemporal trading. It allows postponement of emissions reduction by borrowing emissions permits from others (other areas) or from the borrower's own future permits. Among the parameters, "r" and "t" encourage borrowing, while "p" and "s" discourage it. When CDRn <1, borrowing can yield greater benefits in present values than the costs to be incurred in the future. As a result, borrowing is in advance and results in lower cost of emissions reduction. No intertemporal trading takes place when CDRn = 1. However, these are cases in which intertemporal trading is made by a single unchanged economic entity. When intertemporal trading paired with spatial trading is conducted by more than two countries, it is affected by the magnitude of the gradients of the marginal reduction cost curve in addition to the magnitude of CDRn. At any rate, banking or borrowing takes place in an effort to minimize the "difference" between a theoretically optimal reduction and a reduction target given as an exogenous postulate.

4.3. The Simulation of World Energy Industry -Emissions Trading Model

On the basis of these considerations, simulations were made to demonstrate the effectiveness of intertemporal trading by improving a "World Energy Industry – Emissions Trading Model," which originally had an inter-area emissions trading function, by the addition to it of an intertemporal trading function. In specific terms, in addition to the 2010 proposed under the Kyoto Protocol, the commitment periods were punctuated every five years at 2015, 2020, 2025 and 2030, and two scenarios were prepared for running the model. One is the "Business As Usual" scenario, in which the Kyoto targets remain unchanged even from 2010 onward. The other is the "Tougher Environmental Constraint" scenario, which assumes that the Kyoto targets for stabilizing CO_2 concentrations will become tougher in the later commitment periods. Given the principal four parameters, all having an influence on intertemporal trading, as postulates, each scenario was simulated in 36 cases by varying the banking and borrowing conditions. The simulations results showed that, thanks to its temporal flexibility, intertemporal trading is capable of lowering the GHG reduction cost by 3 – 20% in the BUA scenario, and by 5 – 7% in the TEC scenario, thus explicitly confirming its effectiveness in cutting reduction costs.

4.4. The Emissions Trading Systems as Environment Policy Options

Whether quantitative or qualitative, or spatial or intertemporal, emissions trading should not be restricted to begin with. The economic efficiency of inter-area (spatial) emissions trading has been confirmed through experimental economics applied to emissions trading. The entities responsible for emissions trading can be either national governments or enterprises, but the latter appear to be more competent in making market mechanism-based adjustments efficiently. Also, while a world emissions trading market will be institutionalized when the Kyoto Protocol is ratified, the matter of whether or not a domestic emissions trading system should be introduced is left to the discretion of individual governments. In order to make internationally traded permits tradable at home – i.e., to make the world and domestic markets consistent –the introduction of a domestic trading system into Japan, with enterprises acting as trading entities, is recommended. Regarding the volatility of the price of tradable permits stemming from use of the market mechanism, installing an environmental taxation-combined mechanism can be an adequately effective option in curbing excessive volatility.

5. THE STRUCTURE OF THE PAPER

This paper is structured as follows:

1. "Definition of Theme of Study," in which the aim of the paper is stated. This paper is unique in that it elucidates the grounds for effectiveness of intertemporal emissions trading.

2. “Emissions Trading as Environmental Policy Options,” which discusses the significance of emissions trading as an economic instrument of environmental policy and the positioning of emissions trading under the Kyoto Protocol. An evaluation of emissions trading is made in comparison with environmental taxes.

3. “Emissions Trading Mechanism,” in which general descriptions of emissions trading in a broad sense are given. This is followed by an explicit discussion of what points of emissions trading are in dispute during the talks on the Kyoto Protocol implementation rules. Future subjects are also cited.

4. “Flexibility of Emissions Trading,” which focuses first on the efficiency of the emissions trading market. Specifically, emissions trading, when functioning as a mechanism to adjust the “difference” between a theoretically optimal amount of GHG reductions in economics and a given reduction target under the Kyoto Protocol, can demonstrate flexibility that is helpful in optimization in two dimensions – spatial and intertemporal. This paper focuses on the latter, which has seldom been discussed so far.

5. “Evaluation of Effectiveness of Intertemporal Emissions Trading,” the key point of this paper, which first clarifies the theoretical grounds for the effectiveness of intertemporal emissions trading by using a theoretical model (a two-country two-period model) (Fig. 1), and then analyzes four possible cases geometrically and algebraically. Subsequently, by running a “World Energy Industry – Emissions Trading Model” (LP model) (Fig. 2), the effects of intertemporal emissions trading are simulated in specific terms.

6. “Deterring Tradable Permit Price Rises,” in which it is suggested that the volatility of the price of tradable permits should be checked by a system paired with environmental taxation. This advocates that “utilization of market mechanism” crucially requires an appropriate market design and market construction that can prevent “market failure” – the reverse side of the coin.

6. CONCLUSIONS

“Problems of the Kyoto Protocol and Recommendations,” which contains the conclusion of this paper. It is concluded that the Kyoto Protocol designed to achieve GHG reductions is a product of compromise of international politics, and that the Kyoto targets given to individual countries are far from being optimal solutions. Accordingly, adjusting the “gaps” is the key role of emissions trading; this is a matter of such great importance that emissions trading should not be restricted in any way. In particular, the last point cited is crucial to getting the United States back in the framework of the Kyoto Protocol. This requirement, if satisfied, will eventually lead to worldwide warming abatement efforts that include the developing countries.

7. REFERENCES

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