Emissions Trading Experiments: Investment Uncertainty and Liability

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Abstract: We conducted three experiments on emissions trading. In experiment 1, we found very high efficiency under no investment uncertainty. In experiment 2, we introduced irreversibility of investment and investment time lag. Under these conditions, we found two cases: the success case and the failure case. Then we introduced three liability rules: seller's liability, Kyoto-first liability, and country-first liability. We found a new case called the theoretical price increase case under country-first, and the intentional bankruptcy case under Kyoto-first.

Keywords: emissions trading, liability, Kyoto Protocol, and investment uncertainty

1. INTRODUCTION

Emissions trading is regarded as a cost-effective tool to reduce greenhouse gases. Consider an example. Suppose that reduction cost of one unit of greenhouse gases (GHGs) in Japan is 10, and the cost in Russia is 1. If each country must reduce one unit of GHGs respectively, then the total cost would be 11. On the other hand, if Russia reduces two units, then the cost would be 2. That is, Japan pays some amount of money between 1 and 10 to Russia, and asks Russia to reduce one unit of GHGs in return, that is called emissions trading.

The sum of benefit and profit with emissions trading in the above example is 9 (=10+1-2). What would happen if 0.6 unit of trading in the example? Then the cost of Russia is 1+0.6=1.6 and the domestic reduction cost in Japan is (1-0.6)10=4. Therefore, the sum of benefit and profit of both countries become 5.4(=11-1.6-4). Since the maximum sum of benefit and profit is 9, the efficiency of 0.6 unit of trading becomes 5.4/9=60%. One of our concerns in emissions trading experiments is to find what type of institutions would result in high efficacy.

The above example describes trading only. In order to attain further reduction, it is necessary to introduce reduction investment such as new instruments. “When” and “how” reduction investment is carried out is important decision variables as well as its trading. In order to understand how emissions trading really works, we conducted three major experiments.

2. EXPERIMENT 1

Hizen and Saijo [2001, 2002] conducted 13 sessions using 78 subjects in 1998. This experiment assumes reversible investment. Reversible investment means that even after investment decision, the decision maker can stop the investment and return to the original plants. Under this rather unrealistic assumption, they observed that emissions trading attains extremely high efficiency regardless the choice of trading methods and information closure and disclosure. That is, getting rid of the real nature of investment and paying attention to trading, they observed high efficiency. The reason why they conducted reversible investment experiment is that they want to compare the results with reversible and irreversible investment. Bohm [1997] also obtained a similar result.

3. EXPERIMENT 2

Hizen, Kusakawa, Niizawa and Saijo [2001] conducted 12 sessions using 72 subjects in 1999. When they introduce reversibility of investment, they found two patterns of price dynamics in emissions trading.

The first one is the "failure" case. Emissions permits are traded with relatively high price around the beginning of a session. For this reason, several countries consider that reduction investment is profitable, and hence they conduct investment actively. This causes over-investment worldwide, and hence results in excess supply of emissions permits. Nonetheless, the transaction prices do not go down due to the relatively high price at the beginning and its inertia. Therefore, the price of permits slumps at the end of the period. The economic efficiency of this pattern is quite low.

The second one is the "success" case. Due to low prices of emissions permits around the beginning, each country hesitates about conducting reduction investment. This causes excess demand for emissions permits and hence the pressure of price rise prevails. This results in gradual price increase, but not quite due to price inertia. Each country starts domestic reduction in accordance with price increase, but it is not sufficient enough to attain the Kyoto target. Therefore, the countries that demand emissions permits conduct excessive reduction around the end of the period in order to avoid non-compliance penalty. The economic efficiency of this pattern is relatively high.

They use two types of trading methods in Experiment 2: bilateral trading and auction. Auction is not necessarily better than bilateral trading from the viewpoint of efficiency. Six out of seven success patterns fall into the method of bilateral trading. In auction, every subject can take a look at all information of trading instantaneously since everything is revealed to subjects. Therefore, subjects can respond to the informational change very quickly. On the other hand, in bilateral trading, a pair of subjects must communicate each other and hence it takes a considerable amount of time. It seems that this "friction" of the trading method makes the system stable. They also use two types of information control: informational disclosure and closure. This control does not influence to the results of experiment.

There are other experiments conducted by Baron [2001] of International Energy Agency (IEA), Unipede, and others that are very similar to Experiment 2. The price dynamics in these experiments falls into the "failure case." Subjects in the experiments faced pressure on the compliance of the Kyoto Protocol and therefore responded excessively through excess investment. It seems that subjects in these experiments behaved that way.

4. EXPERIMENT 3

Kusakawa and Saijo [2002] conducted 18 sessions using 90 subjects. Our attention is liability of emissions permits in addition to trading methods and information disclosure based upon Experiment 2. Since the number of sessions is not enough to conduct statistical analysis, the following are our tentative findings.

There are two types of liability in emissions trading among countries: liability of trading among countries and liability to the Kyoto Protocol. Regardless the status of reduction in a seller country, she must provide emissions permits following the contract, which is called "seller's liability" system. Experiments 1 and 2 implicitly assume this liability rule.

On the other hand, a buyer country might not be able to receive all emissions permits based upon the contract depending on the status of seller countries, which is called "buyer's liability" system. No detailed analysis has been conducted on buyer's liability system so far. In our experiment, we designed two types of buyer's liability system depending on the order of liability. The "country-first" liability system is that trading liability among countries has its priority and "Kyoto-first" liability system is that the promise in the Kyoto Protocol has its priority.

In addition to the liability rules, it is important how to design the "default" system when a country cannot achieve the trading contracts to other countries. That is, the order of defaulting countries and the chain reaction among the countries influence the final results of balance sheets. We designed a default system that is independent of the order and the chain reaction. The other design is the penalty system when a country cannot attain the target of the Kyoto Protocol.

Consider the case where a seller country is not penalized when she cannot deliver emissions permits to buyer countries and at the same time the Protocol imposes monetary penalty when a country cannot attain the target. Under the "Kyoto-first" liability system, in order to avoid penalty, a country must keep emissions permits to achieve the target of the Kyoto Protocol. But, once she keeps the permits that clear the target, she does not care about the trading of emission permits among countries. That is, the country might cause default intentionally since she does not have to deliver permits as she promised under this liability system.

On the other hand, under the "country-first" system, a country must submit permits to the Kyoto regime in order to avoid penalty *after* clearing the transactions among countries. Therefore, the probability of default of "country-first" would be smaller than that of "Kyoto-first."

Marrakesh Accords employed the seller liability in the Kyoto Protocol. However, it would be inevitable to use futures transactions even under the seller liability system soon. In this sense, Experiment 3 is intended to the post-Kyoto regime as well as the Kyoto regime.

Our experimental controls in Experiment 3 are

(a) liability system (seller, country-first, and Kyoto-first)
(b) trading methods (auction, and bilateral); and
(c) contract information (disclosure, and closure).

Under this design, we have 12 (=3x2x2) institutions that should be considered. But, since the information under auction is revealed to every subject, we cannot conduct sessions with auction and information closure. Therefore, we have 9 different institutions. So far, we conducted two sessions for each institution.

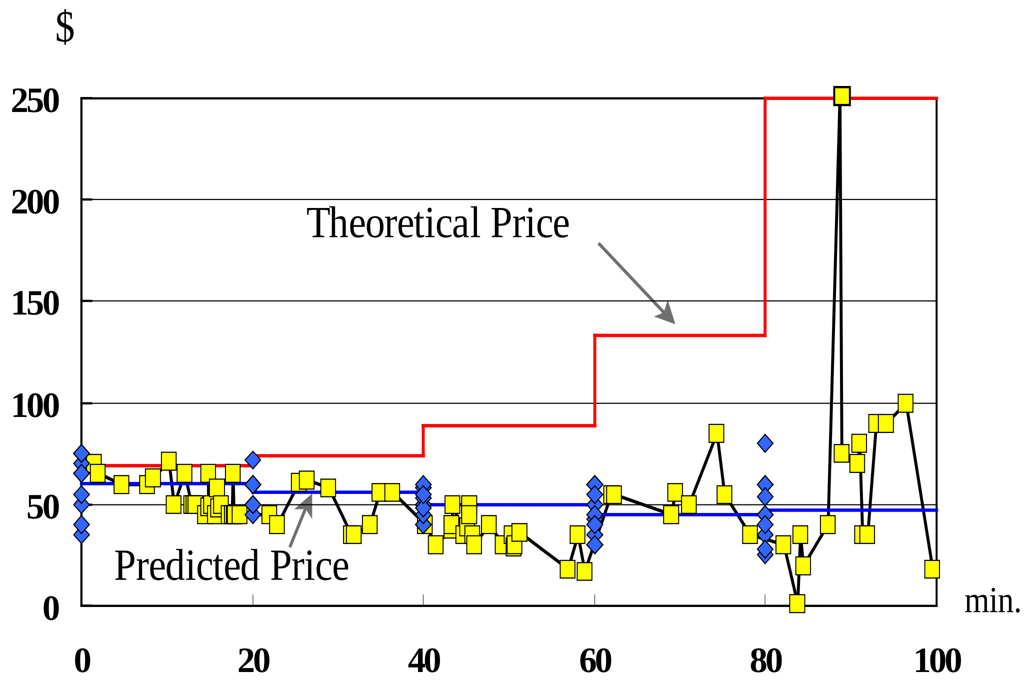

Figure 1. An Example of a Session

Figure 1 shows a session. The horizontal axis is for time, and twenty minutes are regarded as one year. The vertical axis represents price. At the beginning of each year, ten subjects make a guess on the average price in this year, and then conduct reduction investment. The diamonds in Figure 1 show price prediction of each subject and the average of price prediction of all subjects is represented by the line graph. After the decision of reduction investment, we can find a theoretical price level that equates the quantity demanded and supplied. We also show this line graph too. Notice that this theoretical price level cannot be observed in real data in emissions trading. On the other hand, experimenter can observe this price dynamics since she knows demand and supply curves. Squares in Figure 1 show actual transactions in our session. Due to inefficient reduction investment, the transaction prices around the beginning are not high enough although the theoretical price gradually goes up. The transaction prices toward the end show yo-yo, but this does not reflect actual demand and supply. We name the area between two lines, the price prediction line and the theoretical price line the *discrepancy area*. When the price prediction line is below the theoretical price line, we put minus to the area. The discrepancy area is regarded as the degree of "bubble." In other words, if it is positive and big, the expected transaction prices are much greater than the theoretical price that equates demand and supply.

Figure 2 shows the locations of all 18 sessions. The horizontal axis shows efficiency and the vertical axis show the discrepancy area. First, look at the seller liability sessions represented by circles. Then these six sessions are classified as the "failure" and the "success" patterns that were found in Experiment 2. Second, consider the country-first liability sessions represented by

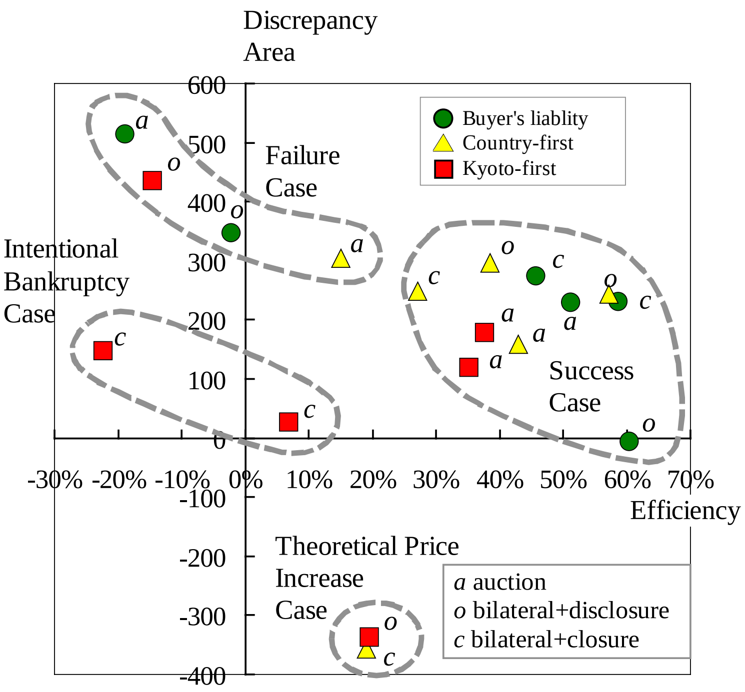

Figure 2. Four Cases in Experiment 3

triangles. Then we find a new pattern called the theoretical price increase pattern in addition to the two cases. This is exactly the reverse case as the failure pattern. That is, due to low transaction prices and not enough reduction investment, the theoretical price goes up toward the end. Figure 1 shows this case. Finally, look at the Kyoto-first liability sessions represented by squares. Then a new pattern called the intentional bankruptcy case shows up in addition to the three cases. In this case, many subjects sold emissions permits in large quantities without conducting reduction investment fully, and hence they intentionally cause default. We cannot obtain clear-cut results on the effect of transaction methods and information disclosure.

The results of Experiment 1 and Experiment 2 were reported in COP4 at Buenos Aires in 1998 and SBSTA10 at Bonn in 1999, and COP6 at Den Hague in 2000. Furthermore, tentative results of Experiment 3 were reported in COP7 at Marrakesh in 2001.

5. CONCLUSIONS

First, we found that irreversibility of investment and the time lag effect play important roles on the efficiency of emissions trading.

Second, the intentional bankruptcy case occurred only in Kyoto-first liability sessions with bilateral trading and information closure. That is, under Kyoto-first liability intentional default did not happen with double auction and bilateral trading with information closure. Under open information, subjects could notice over-selling easily. This finding shows that open information is a key factor in institutional design to avoid intentional default.

Third, we find that country-first liability is better than Kyoto-first liability with respect to efficiency in addition to the default property mentioned above. Negotiators and designers of the Kyoto Protocol could choose Kyoto-first since it is natural, but our experimental results show that this is not.

Fourth, we find almost no difference between seller's liability and country-first with respect to efficiency. However, the variance of efficiency of seller's liability is larger than that of country-first.

6. REFERENCES

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