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Chapter 4
A Highly Simplified Pollution Abatement Game

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Abstract The version of the pollution abatement game presented here, compared to other versions, is simpler for an instructor with a tight timeline looking for an easy and fun way to demonstrate the cost-effectiveness of pollution permits. The absence of equations, tables, or worksheets and the presence of tangible objects makes this version less effort-intensive, more intuitive, and more fun than other versions. The idea behind the creation of this version has been to make the game more like playing monopoly and less like doing taxes. The players in this version hold their wealth in the form of tangible objects, pay taxes using poker chips, and calculate the social cost of abatement by adding up fridge magnet numerals on a collection plate.

4.1 Introduction

Pollution abatement games are an excellent way to help students grasp the strengths and weaknesses of various pollution abatement policies such as command and control, tradable pollution permits, and pollution tax. The games presented by Walbert and Bierna (1998) and Hazlett (1995) are classics. Ando and Harrington (2006) present a simplified version that makes fewer assumptions about the economics background of the players. Corrigan (2011) presents a variation which allows the instructor to demonstrate and compare the cost-effectiveness of the permits and tax policies under realistic conditions such as abatement costs uncertainty and information asymmetry.

These games, however, are quite complex, and require more time, exposure to the economics, and willingness to perform more math than is necessary to grasp the one big lesson—that market-oriented policies such as pollution taxes and tradable permits are relatively cost-effective compared to a command and control policy. Ando and Harrington (2006) present a game which, albeit simpler, requires players

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to solve equations and fill out worksheets in order to figure out their abatement costs. Corrigan (2011) encourages firms to think strategically and overstate their abatement costs, and asks the regulator to anticipate, estimate, and compensate for such overstatement.

A likely consequence of such complexity is that time-pressed instructors facing students with limited exposure to the economic way of thinking (such as in a "Global Economy" course that I teach for students majoring in International Studies) will give such games a pass. This would be a shame, since much of the complexity is not required for a game to be useful for students in, say, an international relation course to understand the cost-effectiveness of a global cap-and-trade regime. Even if such an instructor were to valiantly attempt the game, some students might get too bogged down in calculating their marginal costs to be able to get the "big picture." A weary student might end up concluding that the classroom game was nothing but a problem set with some role-play thrown in.

This paper presents a highly simplified version of the pollution abatement game I have devised for my courses. Players are not required to perform long calculations. Their costs are as conspicuous to them as bright colored fridge magnets can be. Their wealth is represented by tangible items held in their hands, and so their gain and loss are immediately obvious. The decision making required of them here is therefore quicker and more intuitive, and decisions of their neighbors more transparent. Their attention is consequently free to wander towards other aspects of the game such as what the other players are doing and how their choices interact. They are thus more likely to grasp the underlying logic of a policy regime. Finally, being handed poker chips and fridge magnets, rather than worksheets and calculators, calls forth within them a touch of playfulness and strengthens students' mental association of positive feelings with learning.

The trade-off of such simplification is, of course, that the robustness of the main lesson (market-oriented policies reduce pollution at the least cost) cannot be demonstrated under more realistic and complex situations. I find the gains in student engagement, enjoyment, and insight to be worth the trade-off.

4.2 The Setup

Time required: 50 min, including discussions.
Needed items:

- 400 poker chips
- 2 sets of fridge magnets in the shape of numerals 0 to 9
- 10 pieces of paper that say "pollute one," or anything that can serve as pollution permits
- a collection plate labeled "the total social cost of reducing pollution"
- recommended: a hat (or anything else that could serve as a visible sign that the instructor is speaking in the role of the pollution regulator).

4.3 Conducting the Game

I start out by grouping students into 10 teams and handing out to each team:

- 40 poker chips (while announcing that each is worth $1)
- 2 randomly chosen fridge magnets
- the following instruction sheet for all teams (while giving them time to read it and seek clarifications)

Information Sheet for All Teams

The Game

The game ask you to observe and discuss the strengths and weaknesses of three pollution abatement policies: (i) command and control, (ii) tax, (iii) and tradable permits. Each round will implement one policy.

Your Team's Role

- Your team is a firm generating two units of pollution every year when there is no regulation.
- Your team's wealth ($) = number of poker chips + sum of your two fridge magnets.
- The value of each fridge magnet numeral represents the abatement cost ($) for a unit of pollution you produce.
- Your team's goal in each round is to maximize its wealth while complying with the regulator's pollution control policy. In this context, that would mean preserving as much of wealth as possible.

Your Instructor's Role

- Your instructor is a pollution regulator, whose goal is to limit the society-wide total number of pollution units.
- There will be three rounds, and in each round the regulator will experiment with a different policy.

How to Play the Game

- The regulator will begin each round by announcing a policy and the actions that firms should undertake to comply.
- Then a collection plate labeled "total social cost of reducing pollution" will be passed around.
- Each team must give up a certain number of poker chips, or one (or both) of your fridge magnet(s), in accordance with the regulator's policy.
- If you give up a fridge magnet, it means that you have abated your pollution emission by one unit, and bore the cost equal to the value of the fridge magnet.

I create on the blackboard Table 4.1 to be filled in at the end of each round.

Table 4.1 Blackboard table

	Total social cost of abatement ($)
Round 1 command and control	
Round 2 pollution tax	
Round 3 tradable permits	

Before the rounds begin, I announce, "my target as a regulator is to allow pollution emission of no more than 10 units." In interest of simplicity, I have set the target equal to the number of teams, which also works out to be the half the number of pollution units emitted in the absence of regulation. I point out to players that each player has different pollution abatement costs, and ask them to think of reasons why that might be the case (such as different technologies).

4.4 Round One

I begin by announcing "In this round I am going to control our pollution levels by commanding that each firm abate its pollution by one unit." I pass out the collection plate, and to comply each team must give up a fridge magnet.

If I see a team about to give up its higher-value magnet, I remind them about their wealth maximization goal. This is usually sufficient to ensure that all teams abate their unit with the least cost. I retrieve the fridge magnets from the collections plate and note their sum of on the *Total Social Cost of Abatement* table on the blackboard.

4.4.1 Discussion Questions

(i) *Was this policy able to limit pollution in a way that was minimized the total social cost? Why or why not?*

To illustrate the fact that the total cost of the policy was not minimized, I point to one of the magnets (e.g., a "4") still held by a team and compare it to one of the magnets (e.g., a "6") on my collection plate. It shows that a pollution unit with lower abatement cost ($4) continues to be emitted while another unit with a higher abatement cost ($6) does not.

(ii) *Is this policy equitable? Why or why not?*

It could be argued that the policy is equitable in the sense that each firm is required to reduce pollution by the same amount. But since firms have different costs of abatement, some people might consider the burden of abatement to have been distributed inequitably.

(iii) *Suppose that to minimize the total social cost of abatement, a real-world regulator were to require only the firms with low costs of abatement to curb pollution. What problems might arise?*

It would seem patently inequitable to have only some firms bear the entire social cost of abatement. Also, the regulator has less knowledge about each firm's abatement costs than the firms themselves do, and so the firms would have an incentive to overstate their costs in order to avoid being required to abate.

At the end of each round, I return to each team the fridge magnet numerals placed on the collection plate.

4.5 Round Two

I announce that "the policy of this round is a pollution tax. For each unit of pollution that you emit, you must pay a $4.99 tax using your poker chips, or else abate." When I pass out the collection plate, each team must either give up (i) both fridge magnets, or (ii) one fridge magnet and $4.99 worth of poker chips, or (iii) $9.98 worth of poker chips. Since each team has poker chips of $1 denomination only, they will need to put $5 of poker chips on the plate. If they ask for a penny back, I announce "No change is given. I can give you credit worth a penny though."

To preserve its wealth, each team should be giving up its fridge magnet numerals of value less than 4.99, but pay the tax to keep the numerals of value greater than 4.99. There would exactly 10 such magnets. I have chosen the tax amount to be $4.99 rather than $5, so that those with the magnets "5" will not abate. It is necessary, given the setup of the game, to ensure no more than 10 units are abated. If I see a team about to give up a numeral that is a "5" or higher, I ask them to explain openly how they arrived at their decision. Doing this one team is usually sufficient to get all teams on the right track.

I retrieve the fridge magnets from the collections plate and note their sum on the appropriate line in the *Total Social Cost of Abatement* table in the blackboard. The sum is inevitable lower than under command and control.

4.5.1 Discussion Questions

(iv) *Why was the policy able to limit pollution at lower total social cost than command and control?*

To illustrate the reason, I point to the fact that all the magnets on the collection palate are lower than "5." Only units with an abatement cost lower than $5 were abated.

(v) *What are some of the problems that a regulator might face in setting the tax rate?*

One possible answer: the regulator might not know the distribution of the abatement costs among the units emitted, as such information is known privately by the firm, and they might not be willing to report it accurately. Without such knowledge, the regulator might not be able to predict accurately the number of pollution units that will be emitted at any given tax rate, making it hard to hit a target. I ask students to consider, for example, how many more units of pollution would have been emitted if I had set the tax rate at $3.

4.6 Round Three

I start by handing out a permit to each team and making the following announcement:

> You cannot pollute in this round without a permit. Each permit you possess will allow you to emit one unit of pollution. Everyone has been granted one permit for free to start.
>
> There will be a 4-minutes trading period for pollution permits. You can either buy or sell a permit using poker chips at the market price, determined by a Walrasian auction.
>
> I will call out a price. I will ask the teams willing to buy a permit at that price to raise their hands. Next, I will ask the teams willing to sell their permit at that price to raise their hands. I will repeat the process for several prices. Only raise your hand if you would increase your wealth at that price. We will set the market price as one for which the quantity of permits demanded is equal to the quantity supplied, or failing that, the one with the smallest gap between the quantity demanded and quantity supplied.
>
> After we set the market price, I will announce the start of a 4-minute trading period, during which you can trade permits with other teams at the market price.
>
> When I come around with my collection plate at the end of the trading period, for each one of your two pollution units you will have to either show me a permit or abate it.
>
> Before I begin the Walrasian auction, I am giving you three minutes to discuss the price range at which your team would be willing to buy or sell a permit. Start by asking yourself: at $1, would it make sense for you to buy a permit, or sell one? At $2? And so on.

Given the wealth maximization goal, it does not make sense for any team to buy a permit for a price higher than its lowest valued magnet, or sell at a price lower than its highest valued magnet. For example, if I have magnets "4" and "6," then for permit prices less than $6 it would make sense for me to keep my permit to use on the "6" while giving up my "4." But it would increase my wealth if I were able to sell my permit for a price higher than $6. Similarly, it would increase my wealth to be able to buy a permit for a price less than $4 so that I can avoid giving up my "4."

To ensure each team has figured out their ranges accurately, I start by asking a team to share them. If their buy and sell ranges are not accurate given their abatement costs, I keep prodding them with questions ("how about at $3? Would you buy at $3? How about $4?") until they arrive at the accurate ranges. It is usually sufficient to do this with one team for others to get the idea.

Once they have determined their buy and sell ranges, I announce the start of a Walrasian auction. The idea for the auction has been adopted from Ando and Harrington (2006). Such auction eliminates the need to discover the market price through a series of potentially chaotic and time-consuming series of bilateral exchanges. It also makes it very likely that the market clears. I, as the auctioneer, carry out the steps explained in the earlier instructions, keeping track of the number of buyers and sellers at each price on a table on the blackboard. Once I have determined the price, I begin the 4-min trading round.

After the trading period ends, I walk around with my collection plate, demanding their fridge magnets unless they can show me permits. I add up the values of the fridge magnets on the plates and announce the total cost of pollution abatement in round three, and note these costs on the table on the blackboard. These costs are bound to be lower than in round one.

4.6.1 Discussion Questions

(vi) *Why was the policy able to limit pollution at lower total social cost than command and control?*

To illustrate why the costs were lowered, I point to a permit trade that took place, and how it allowed a firm with high cost of abatement (e.g., $7) to transfer its abatement obligation to a firm with a low cost of abatement (e.g., $4).

(vii) *Compared to the command and control policy, are the teams buying permits better off? How about the teams selling permits?*

Correct Answer: Yes, all the teams are better off. The teams buying a permit pay a price that is lower than what it would cost that team to abate, and the firms selling a permit gets a price that is higher than what it would have saved by using the permit.

(viii) *Compared to the command and control policy, is this policy more equitable?*

One possible answer: Under the command and control policy, the firms unlucky to have high costs of abatement bore a higher burden of compliance. Now such firms get to buy their way out of abatement at a price that is lower than the cost of abatement, so their financial burden is lower.

(ix) *What about the cost spent on buying permits? Should that be included in the social cost of pollution abatement.*

Correct answer: That money represents transfers between firms, and therefore are not part of the social costs of pollution. One firm lost the money, the other firm gained it, and no real resources were expended (except a small amount to administer the permits market).

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