

Economic Instruction

In this section, the *Journal of Economic Education* publishes articles, notes, and communications describing innovations in pedagogy, hardware, materials, and methods for treating traditional subject matter. Issues involving the way economics is taught are emphasized.

MICHAEL WATTS, Section Editor

The Paper River Revisited: A Common Property Externality Exercise

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Abstract: The author describes a modified version of the Paper River exercise that appeared in this journal in the Spring 1999 issue. The original game was designed to illustrate the application of the Coase theorem for solving an externality problem. In the Paper River, pairs of students share a single productive resource: small pieces of paper. At question is who has the rights to the paper. The author presents a modified version of the game that retains many of the same elements from the original, but the students work in groups rather than in pairs. Doing so increases the transaction costs associated with negotiating a solution. In addition, the productive resource is common property, so property rights are difficult to establish. These difficulties make a Coasian solution more difficult but make the simulation more realistic.

Key words: classroom experiment, externalities, property rights

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The Paper River is a classroom simulation developed by Hoyt, Ryan, and Houston (1999). The experiment is used to facilitate understanding of the Coase theorem (1960) and how property rights can help alleviate the problem of external costs. If transaction costs are small and property rights can be clearly defined and enforced, markets will achieve an efficient solution. In addition, the solution will be the same if property rights are awarded to either party. One of the four examples of this argument appearing in Coase's original work involved a doctor located next to a confectioner. Noise from the confectioner disrupted the doctor's

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practice. The externality exists because there is no clear right to noise or quiet. If the confectioner has the right to make noise, then the doctor will seek out and pay for the least-cost solution to the problem. Awarding the right of quiet to the doctor results in the confectioner paying for the least-cost solution.

In the original Paper River exercise, pairs of students use small pieces of paper as a productive resource. The externality arises when the same paper is used by successive students but for different purposes. The “upstream” student solves multiplication problems using pencil and paper provided by the instructor and earns two points for each correctly solved problem. Subsequently the paper is passed to the “downstream” student who uses the same paper to make paper airplanes. Unfortunately, the paper must be clean to count. Pencil marks left over from the math problems must be erased by the downstream firm. After this demonstration, the instructor attempts to elicit a Coasian solution from the students. Because the paper is not “owned” by either party, there is no incentive for the problem solvers to conserve. For example, some students may solve problems on only one side of each sheet. The problem can be solved by awarding paper property rights to either party. In this case, the property rights to the paper are easily defined and enforced, and the transaction costs associated with a one-on-one negotiation are small. If the problem solvers own the paper, they can earn profit by selling clean paper to the plane producers. If the plane producers own the paper, the problem solvers have the same incentive because paper must be purchased. After the rights are awarded, the game is replayed with less “pollution.”

This is an interesting experiment and replicates the Coase theorem exactly. The authors suggest that the simulation is representative of common problems such as endangered species and rainforest destruction. They suggest, by way of example, that this exercise could simulate two firms located along a river where the upstream firm pollutes the water, and the downstream firm must purify it before use. Because no one owns the water, there is too much pollution.

Unfortunately, most of the common externality examples, including the three the authors cite, are not very similar to the Paper River simulation. For example, on most rivers, there are multiple upstream and downstream users. This situation increases transaction costs and makes a Coasian solution less likely. In addition, as in the case of river water pollution, air pollution, and endangered species, property rights may be virtually impossible to define and enforce. Under many realistic situations, the Coasian solution is virtually impossible.¹ The authors allude to these problems in their conclusion. Fortunately, a relatively modest modification of the original exercise can solve these problems.

The Chesapeake Bay watershed is a good example of the type of situation the modified simulation can represent. The bay is an enormous common property resource serving all manner of recreational and commercial interests, including swimming, boating, fishing, and crabbing (both commercial and recreational). The water in the bay is largely supplied by the Susquehanna River, and the quality of the water in the bay is seriously impaired by commercial interests located upstream. Some of the major polluters are agricultural operations located in Pennsylvania. Various forms of run-off (pesticides, herbicides, manure, salts, etc.) slide down the river and have a negative impact on many users downstream. To be spe-

cific, there are dairy farmers upstream and commercial fishermen downstream. This is the sort of situation the modifications are designed to simulate. Property rights are still at issue; however, transaction costs and the difficulty of constructing an appropriate property right regime make a strict Coasian solution impossible.

EXERCISE MODIFICATION

In the modified version of the Paper River exercise, the general principle of the game is maintained, but features are added to make it more representative of most common externality problems. The modified version can be played in as little as one 50-minute class period or in as many as three periods, depending on the number of features added. It is suitable for both principles and advanced classes. The two major modifications are the introduction of a true common property element and the addition of substantial transaction costs.

The essential elements of the problem are as follows: There are a large number of polluters upstream and a large number of affected parties downstream. Pollution appearing downstream cannot be traced to any particular polluter upstream. Furthermore, two technologies for production exist upstream: a “clean” technology and a less expensive “dirty” technology. Finally, the polluted resource is common property. To carry out this experiment, the instructor will need the following materials:

Small pieces of paper (roughly 4" by 2"), approximately 4 per student,
20 3×2 multiplication problems (on an overhead) and answers,
enough pencils and pens for half the class,
an effective reward mechanism (bonus points or cash, for example), and
one to three 50-minute class periods.

Procedure

The basic structure of the game is the same as suggested in the original article. However, instead of pairing off, the class is separated into two groups. Half the class is randomly selected to produce math problems and the rest to produce airplanes. Unlike the original Paper River, this exercise does not require an even number of participants. The second major difference is that the common resource (the paper) is common property (nonexcludable). Rather than allocating paper to each player, the paper is spread out on a desk before each round and must be returned to the desk after each round. The paper is available to all math producers first (they are upstream), and after it is used, the paper must be returned to the desk. The paper is subsequently available to the plane producers downstream. Making the paper available in this fashion makes it difficult to transfer property rights. Math producers may “own” the paper while they use it, but they are forced to relinquish these rights when the paper is pooled on the desk. In this way, the paper is very much like a river.

In the first round, math-group students clear their desks. Ten multiplication problems are placed on the overhead or chalkboard. Students are told they will be awarded two points for each problem they solve correctly within three min-

utes, and the answers must be recorded on the paper. Pens or pencils must be rented from the instructor. Pens cost 2 points, and pencils cost 4 points. Almost all students will opt for the inexpensive technology (the pens). Paper is available on the front desk. After three minutes are up, students check their answers, record the points on the record sheet, and deduct for the cost of the pens. The instructor then collects the paper and the pens and moves to the second group. This process will take less time if math problems and solutions are prepared on overheads.

Members of the second group are awarded 3 points for each paper airplane they can build on clean paper. (A quick paper-plane building demonstration may be in order.) All the dirty paper should be mixed together with enough clean sheets so that there are approximately two to three clean sheets per person and spread the mixture on the desk at the front of the room. Distribute erasers so the students can clean any pencil marks. Give them three minutes. When the time is up, the instructor records the points. Because the clean paper is essentially up for grabs, the clean paper will be exhausted in a matter of seconds.

At this point, the problem (all the ink) that exists (as well as an apparent solution) will be painfully obvious to all students. If not, from the dirty sheets, the instructor selects one with a small amount of ink: one with writing on only one side, or just one problem, or maybe a single mark. If necessary, you can create a sheet like this yourself beforehand. Somehow, the math people must be convinced to adopt a cleaner production process (i.e., using the pencils or less paper).

At this point, the game can be shut down and the instructor can proceed with a discussion of possible solutions: mandates, taxes, subsidies, and property rights. For example, to illustrate the Coase theorem, the instructor can award paper rights to either group. This solution is impossible to implement, if the paper is pooled on the desk and allocated as common property to the plane group (like the water in the bay). Alternatively, students can be given an opportunity to try to reach some sort of arrangement on their own before they play another round. The transaction costs inherent in a negotiation with many players on each side will usually prevent a timely solution, but this does make for a spirited debate. The instructor may even assign each student the task of drafting a solution (a binding contract agreeable to all parties) for homework. At any rate, there is never enough time in a single 50-minute period for students to solve the problem themselves and play a second round. It may, in fact, take an entire class period just to reach an agreeable solution. The timing here simply depends on how much the instructor is willing to intervene and help the process along. The economics is in solving the problem. Once the problem is solved, however, the outcome of the second round is immaterial and can certainly be canceled.

Additional Variations/Discussions

The game offers ample opportunity for discussion. There is the obvious externality problem with the marks on the paper. A more subtle point is that the best choice of technology hinges on the prices of pens versus pencils and the relative value of airplanes and math problems. The mad scramble for clean paper by plane makers is a striking example of the tragedy of the commons. In lieu of a

solution in the form of a binding contract, free riding becomes an issue. For example, an airplane builder may make an oral agreement to subsidize the purchase of pencils and then fail to contribute.

After the exercise is completed, class time is devoted to a discussion of the nature of externality problems. Specifically, individual incentives at times oppose the public interest. This is an opportune time to discuss the Coase theorem and how property rights might be used to solve the problem, but, more important, that the solution may be independent of the assignment of the property rights. Who pays for the solution implies a property right. In this case, the pencils cost more. If the math-problem students are forced to bear this cost, that implies that the plane makers had the right to clean paper. Alternatively, if plane students bear the cost, then that implies that the math students had the right to pollute.

It may appear to the students that the math producers in this arrangement are harming the plane producers. However, one of the major points Coase (1960) makes in *The Problem of Social Cost* is the reciprocal nature of externality problems. This point is clearly made by allowing the airplane construction to take place first. If (a) the airplane industry is upstream, (b) planes cannot be deconstructed for problem solving, and (c) the supply of paper is sufficiently limited, then in the absence of property rights, it is entirely possible that no math production will take place. Now the direction of harm is reversed. Furthermore, both production processes could take place simultaneously with the same common property resource. In this variation, each plane produced harms a problem solver, and each problem solved harms a plane producer.

After the exercise, students can be assigned homework that requires the students to relate the in-class exercise to a real-world problem. Recently I used a newspaper article that described how a group of trout anglers were upset that a Home Depot was to be built on the banks of their stream. Water run-off from the parking lot would adversely affect the fishing. Students were largely successful at identifying Home Depot as the math problem students, the anglers as the plane builders, and the run-off from parking lots as the ink. Solutions to the problem varied, but most involved some incentive for the Home Depot to take measures to protect the stream. Problems of this nature appear regularly in the popular press. In cases such as this, the instructor might point out that the efficient solution might be to do nothing (let the pollution continue unabated) if the harm done to one party is smaller than the benefits to the other.

In addition to the efficiency issues, a robust equity discussion can emerge, as math or plane people dominate the point totals. Point totals will usually be larger for one group. For example, if the paper is severely limited, airplane totals may be small (particularly in the first round), so they were unlucky. On the other hand, math totals in the first round might have been zero if the plane builders had gone first. An element of bias can be added by rearranging the groups in the beginning of the game based on some observable characteristic. Students could trade places based on eye color so that all the blue-eyed students are in the same group. A Lorenz curve and gini coefficient can be constructed from the point totals. Often the inequality resulting from the exercise is enough to outrage the students but is less than the disparity that occurs in United States incomes. Students readily rec-

ognize that the inequality emerges from randomness, bias, skill, and aggressiveness. In fact, the whole exercise can be devoted to an equity discussion.

This discussion can be used to address student concerns about their point totals. The instructor can explain that points are awarded for solving economic problems (this is stated in my syllabus). In addition, most universities prohibit awarding grades in an arbitrary or capricious manner. Students generally have a keen sense of fairness in a situation like this and seldom object if points are awarded for participation. If the idea of awarding and then discarding points is objectionable, other incentives could be introduced. A monetary reward would work as well, although an equity objection would probably still emerge.

Many modifications to the basic structure of the game can further increase the realism. One possibility is to separate physically math problem solvers and plane producers. Putting math producers in one room and plane producers in a second dramatically increases the transaction costs associated with a negotiated settlement, because neither group fully understands the behavior of the other. In this version, a useful twist is to ask three or four talented students to serve as an independent third party (like the EPA) to help facilitate a solution. In this version, separate the two groups, play round one, and let the observers moderate the discussion between groups. The observers also can be given the power to enforce a binding agreement. Although more realistic, this version can add up to two additional 50-minute periods to the exercise.

CONCLUSION

This version of the Paper River problem provides a more realistic version of a typical externality problem than that which appears in the original Paper River design. The original game is contrived so that the externality can be internalized by assigning property rights. Although this is a useful exercise, many common externality problems exist because property rights are not easily defined or enforced. In this modification, students are immersed in a situation in which individual incentives run counter to the social interest and are given an opportunity to solve the problem themselves. Assigning property rights can, theoretically, still solve the problem, but the exercise exposes the weakness of the strict Coasian solution in cases in which it is costly or impossible to effectively delineate property rights.

NOTE

1. Cropper and Oates (1992) provide a survey of both market and regulatory solutions to externality problems, and Anderson and Leal (1991) provide a thorough treatment of property-rights-based solutions.

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