

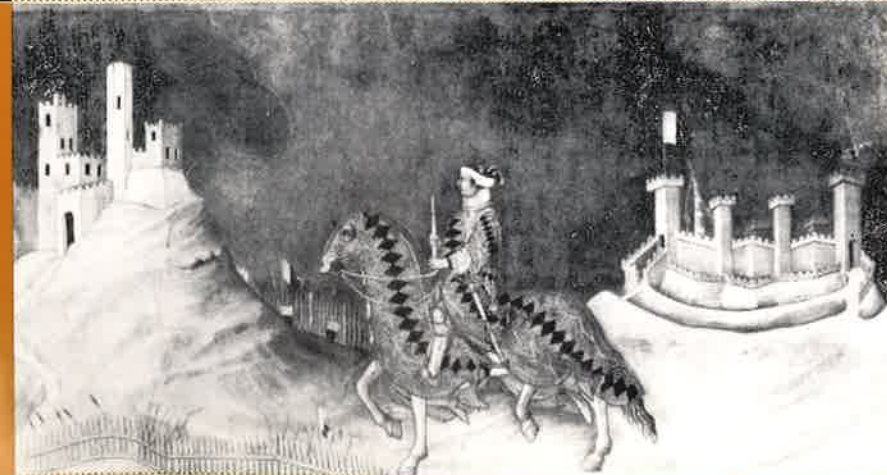
UNIVERSITA' DEGLI STUDI DI SIENA



QUADERNI DEL DIPARTIMENTO
DI ECONOMIA POLITICA

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A SCHEME TO ALLOCATE WASTEWATER RIGHTS



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Luigi M. Tomasini

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Siena, marzo 1989

* 1. As economies grow many resources tend to become scarce, even air and water. Although the atmosphere and water courses have limited capacities to absorb wastes, their assimilative capacities are provided free to anyone who wishes to use them. To prevent environmental problems which an overuse of this capacity implies, economists to regulation have traditionally preferred market incentives, such as taxes and charges.

The literature on the argument is extensive and no attempt will be made here to survey it. The aim here is narrower and more modest, and impinges on developing an allocative mechanism of discharge coupons for water quality management, where each coupon grants the right to discharge a given bundle of wastes into the water.

The price system considered is more cost-effective and efficient than the one which set standards. In fact, as the cost of eliminating or reducing wastewater is lower for the pricing system than for the set-standard one, more goods and services can be produced in the economy. Furthermore, the adoption of the pricing system grants to different potential users the right to bid for those discharge coupons, i.e grants the possibility of allocating these rights to the most socially desirable uses.

It is to be pointed out that in this framework all non-user parties, such as conservation groups and speculators, are allowed to buy discharge coupons. The conservationists may want to buy some coupons to prevent their being used -and hence reduce waste water pollution-; the speculators to profit from their exchange in the discharge rights markets.

The problem we wish to investigate concerns the allocation of wastewater coupons (rights) among units who generate and discharge wastes. The fairness in the mechanism we suggest is reflected by the requirement that the resulting assignement of the wastewater coupons be acceptable by all n units.

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The model we suggest can be described as follows. A central authority which reflects the social welfare function of all individuals in a system fixes the total quantity of waste which can be discharge into a water course. Each unit assigned a wastewater coupon has the right to discharge a given amount of waste into the water.

The allocation mechanism we suggest below will be considered fair by the n unit because:

- (i) valuation of the right to discharge a given amount of waste by each unit is subjective;
- (ii) if two or more units have different values for the wastewater coupons, there exists an assignment which gives each unit more than its fair share, and
- (iii) each unit will obtain a value at least equal to $1/n$ th of the total value of the wastewater coupons, where n is the number of units competing for the coupons.

2. Let v_{ij} be the value of the i th ($i \leq m$) coupon as determined by the j th unit ($j \leq n$). For m coupons and n units, we have a coupon value matrix $V = [v_{ij}]$. Summing the elements in each column in V , we obtain for each unit the total value of all m coupons. Dividing these sums by the number of discharge units n , results in the "fair share" values of the coupons, i.e.

$$(1) \quad v_j = 1/n \sum_i v_{ij}, \quad j = 1, \dots, n.$$

Let us indicate by $C = [c_{ij}]$ an assignment matrix where $c_{ij} = 1$ if the i th coupon is assigned to the j th unit and where $c_{ij} = 0$ if it is not. For each i , let $c_{ij} = 1$ for the j th unit for which

$$(2) \quad v_{ij} = \max_j v_{ij},$$

i.e., the unit which attaches the highest value to the i th coupon.

Finally, let us define y_j as the monetary side-payment made by (or to) the j th unit, where the sum of all side-payments equal zero; that is,

$$(3) \quad \sum_j y_j = 0.$$

The method of allocating coupons may be described as follows. First we assign each coupon to the unit which offers the highest price for it. Then we find the side-payments (which sum to zero) among the n units so as to produce an equal surplus over the fair share value for each unit. The amount of this surplus for each unit is given by

$$(4) \quad S = 1/n \left\{ \sum_i (\max_j v_{ij}) - \sum_j 1/n \sum_i v_{ij} \right\}.$$

Assuming for the i th coupon that $\bar{c}_{ij} = 1$ for the j th unit for which $v_{ij} = \max_j v_{ij}$, the problem is to choose y_j and S so as to maximize S subject to

$$(5) \quad \sum_i v_{ij} \bar{c}_{ij} + y_j - v_j \geq S \quad j = 1, \dots, n,$$

$$(6) \quad \sum_j y_j = 0.$$

Adding up the first set of constraints we have

$$(7) \quad \sum_{ij} v_{ij} \bar{c}_{ij} - \sum_j v_j \geq n S.$$

Choose now

$$(8) \quad \bar{S} = 1/n \left\{ \sum_j (\max_i v_{ij}) - \sum_j v_j \right\},$$

so to have equality in the sum and hence equality in all of the inequality summands. Equation (8) tells us that the surplus is at its maximum when it equals

the difference between the sum of the maximum valuation of the m coupons and the sum of the fair shares.

It can be easily shown that $\bar{S} \geq 0$ independently of the valuation made by the n units. Furthermore, by (5) which is clearly (by the appropriate choice of $\bar{S} = S$) an equality, we obtain

$$(9) \quad \bar{y}_j = v_j - \sum_i v_{ij} \bar{c}_{ij} + 1/n \left\{ \sum_i (\text{Max}_j v_{ij}) - \sum_j v_j \right\}, \quad j = 1, \dots, n.$$

Summing over j all the members of (9), we have

$$(10) \quad \sum_j \bar{y}_j = \sum_j v_j - \sum_{ij} v_{ij} \bar{c}_{ij} + \left\{ \sum_i (\text{Max}_j v_{ij}) - \sum_j v_j \right\} = 0,$$

which verifies that

$$\sum_j y_j = 0.$$

In equation (9), the three terms are respectively, the fair share, the value of the i th waste coupon assigned to the j th unit, and the "surplus".

The rule of fair allocation suggested is valid only if we assume that no unit, knowing the other units valuation, will "cheat" by giving a false valuation of waste coupons. In fact this assumption is, however, not too stringent if we imagine a system with a very large number n of units.

3. To illustrate the role of fair allocation suggested we can formulate the following example.

Suppose we have four units and three coupons each allowing the right to discharge a given amount of waste into a river. All four units are entitled to receive a share of the total value of those coupons.

WASTEWATER DISCHARGE COUPONS	DISCHARGE UNIT			
	1	2	3	4
1	6	11	7	9
2	2	2	4	2
3	2	1	1	1
Total	10	14	12	12
Fair share	2.50	3.50	3	3

The three coupons (1,2,3) will be assigned, respectively, to the second, third and first units. Furthermore, each unit should receive (+) or pay (-) the amount of money given in the side-payment column.

The rule suggested assumes that no unit, knowing the other units valuation, will "cheat" by giving a false valuation of discharge rights. In fact if one misrepresents and the others are truthful, the cheater can get, up to a certain level, an additional return (i.e. a higher share). Beyond that level, the more he misrepresents the higher is the side payment he must pay to the others and consequently his loss.

It is interesting to note that true valuations are a winning strategy even when the others are cheating. In fact, the more the others misrepresent the more dangerous is for him to do so.

4. The model suggested has several prominent characteristics:

(1) The public authority (at local or regional level) decides which are acceptable levels of wastewater to be produced in the economy. The process by which such levels are chosen is an adaptive one being a function of many socioeconomic

variables. In particular, it reflects some kind of present as well as future social welfare function.

(ii) The units which will not be granted the rights to produce a given quantity of wastewater will receive a monetary compensation that will allow them to finance research and development for new techniques which are either more profitable or that produce goods with a reduced wastewater content.

(iii) The public authority, deciding upon levels of acceptable wastewater, influences R and D towards techniques which are less polluting. The decision on what to produce is left to the working of the market. The government intervention influences individual choices, drives out of the market firms not efficient and promotes equity.

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