THE ROLE OF ENFORCEMENT AND ECONOMIC INSTRUMENTS IN INDUCING ENVIRONMENTAL INVESTMENT IN A TRANSITION ECONOMY: THE WATER SECTOR IN ROMANIA

Clifford Zinnes, Cornel Tarhoaca, and Mihaela Popovici

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Clifford Zinnes is an Associate at the Harvard Institute for International Devlopment and C4EP's Senior Environmental Policy Advisor in Romania. Mihaela Popovici is the Executive Director of the Center for Environmentally Sustainable Economic Policy in Bucharest, Romania. Cornel Tarhoaca is an assistant professor of economics at the Academy of Economic Studies, Bucharest, Romania.

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For additional information please contact: International Environment Program, Harvard Institute for International Development, One Eliot Street, Cambridge, MA 02138.
Tel: (617) 496-5176. Fax: (617) 496-8040

ABSTRACT

Great attention has been placed over the years on the choice and design of economic instruments for a more efficient allocation of environmental goods and services and to stimulate environmental investment in such a way as to reduce the society-wide costs of attaining a desired level of environmental quality. Such policies, falling under the rubric of "getting the prices right", presuppose that, once set, the prices will be paid. However, in the transition economies of Eastern Europe not even existing low prices for environmental goods and services are paid, let alone the presumably higher prices entailed by economic instruments set at allocatively efficient levels. Instead, compliance – such as it is – occurs through explicit and tacit negotiation and persuasion. Moreover, the region is undergoing massive privatization, the most powerful economic instrument of them all, whose effect in the name of profit is to reduce waste but also to take advantage of regulatory weakness. Taking as an example the water sector in Romania, the present paper develops a simple theoretical model of enterprise compliance in the context of the non-payment and an endogenous level of enforcement on the part of the water authority. The model is then econometrically applied at the level of the enterprise and the river basin to analyze the roles of enforcement and economic instruments in stimulating environmental investment in the presence of privatization. The paper ends with policy recommendations and the prediction that privatization on net will improve environmental quality.

1. INTRODUCTION

A principal challenge in transition economies is to stimulate an optimal level of investment in environmental compliance and abatement (Daley, 1990). The historical use in these economies of command and control methods for this purpose, though, has been shown to be costly, both in theory and in practice (Markandya, 1992). Unfortunately, the conditions being placed on Eastern European countries for accession into the European Union include the achievement of even higher levels of environmental compliance. Great attention has been focused, therefore, on the choice and design of economic instruments with the aim of "getting the prices right" so as to generate a more efficient allocation of environmental goods and services and to reduce the society-wide costs of environmental compliance (Panayotou, 1994).

These policies presuppose that, once set, the prices will be paid. However, in the transition economies of Eastern Europe not even existing low prices for environmental goods and services are paid, let alone the presumably higher prices entailed by economic instruments set at allocatively efficient levels. Instead compliance such as it is occurs through explicit and tacit negotiation and persuasion. Moreover, the region is undergoing massive privatization, the most powerful economic instrument of them all. While privatization leads to a greater responsiveness to price incentives (so a given level of pollution charges should lead to a higher level of environmental quality), the profit motive and competition encourage the privatized enterprise to take advantage of weak enforcement, thereby pushing regulatory limits.

The present paper develops a decision-theoretic model of the enterprise non-compliance problem in the face of non-payment and where the probability of inspection on the part of the regulatory authority is endogenous. The model is then econometrically estimated, accounting for the degree of privatization, and used to analyse the role of enforcement and economic instruments in stimulating enterprise investment in abatement in the context of the water sector in Romania. The water sector is particularly good to study given that it takes on aspects of both a good as well as a service. Based upon these theoretical and empirical results, the paper ends with a series of policy recommendations related to the introduction of economic instruments in a transition economy.

2. INSTITUTIONAL AND POLICY BACKGROUND IN THE WATER SECTOR[1]

Romania is a country of 23 million people. Water resources include the Danube River and twelve tributary basins, as well as the the 650,000-hectare Danube Delta — the largest wetland in Europe — and part of the Black Sea. In addition to having the largest old growth forest reserves in Europe and abundant deposits of ferrous and non-ferrous metals, the country has reserves of oil, natural gas, and coal. This resource abundance, however, has had its costs.[2] The country developed minerals, petrochemical, and metals processing industries that are highly polluting, leading to economic, health, and ecological impacts on an enormous scale.[3] Such impacts have also stymied the development of activities with a potential future, such as tourism and fisheries.[4] While these costs are clear, weak economic growth during the transition has led to understandable trepidation about pursuing too quick or rigorous a program of environmental protection, and economic instruments in particular.

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[1] This section draws on, updates, and extends Zinnes (1997).

[2] This is not unusual internationally. Sachs *et. al.* (1995) show that countries with a greater abundance of natural resources have experienced *lower* long-run growth.

[3] This apparent paradoxical inverse relation between resource abundance and environmental degradation is, in fact, not unusual. See Sachs and Warner (1995) for a description of international experience.

[4] A summary of the worst of these impacts by key economic sector and by health, ecological and economic effect is provided in Manea and Zinnes (1994).

In 1997 and under the newly elected reformist government, an IMF FESAL agreement launched the country on an ambitious privatization program. Strong economic growth is expected as a result. These and other reforms will place new stresses on the environmental regulatory authorities at a time when budgetary austerity imposed by the FESAL will lead to a substantial reduction in personnel and equipment. While options are being considered on how to put regulatory finance onto a sustainable basis and though a comprehensive new set of environmental regulations has been drafted (Zinnes, 1996), enforcement in the near term is certain to get worse. It is important to consider whether the privatization program will generate enterprise investment in environmental protection or will it lead to further environmental degradation as has been found elsewhere (Reed, 1995).

At the same time, stimulated by (i) the new government's campaign commitment to set up an environmental fund, (ii) anticipation of World Bank loan conditionalities, and (iii) pressure to signal to the European Union Romania's seriousness to meet the environmental commitments of the legal approximation process of accession, there is a renewed interest in developing economic instruments. It is thus particularly germane to analyze in the context of Romania what the role should be of economic instruments and of command and control to elicit the necessary level of enterprise investment mentioned above in the future. In order to address these questions, we examine the effects that such polices have played so far in the privatization process on the water sector.

The water sector is regulated by the Water Department located in the Ministry of Water, Forests, and Environmental Protection (MAPPM). The Water Department supervises *Apele Române* (AR), a public utility with branches in each of the country's 12 river basins. AR is responsible for the management of 70,000 kilometers of rivers and 150 multi-purpose lakes and dikes. AR supplies 95% of the raw water to municipalities, industry, and agriculture. Local government is responsible for municipal water supply and wastewater treatment.

Water resources in Romania are administered according to the principles of integrated water management which links water quality and water quantity. This linkage is important because excessive abstractions lower underground and surface water levels, thereby increasing contaminant concentrations and creating the same deleterious environmental effects as effluent discharges. The permitting process, the heart of the regulatory system, incorporates this duality by issuing permits and assessing charges and fines both for water consumption and for effluent discharges. The 12 river basin branch offices of *Apele Române* issue permits based on the national water management strategy specifying the amount of water used or consumed, as well as the quantity and quality of effluents. Water management standards include effluent standards that limit the amount or rate of discharges. Ambient water quality standards also exist. These standards provide some flexibility, because they allow facilities to choose which technologies should be used to meet requirements.

For enforcement, the Water Department of MAPPM and AR can take legal action against non-complying facilities and levy fines and other sanctions — including closure — against violators. Compliance is monitored in many ways. First, AR conducts routine plant sampling and inspections, including the review of the facility's records (enterprises are responsible for monitoring and reporting their discharges). While the number of inspections are planned, the timing of the visit is not known to the enterprise. Second, AR carries out unplanned plant visits, usually based on concerns raised from other inspections. Third, when an accident is reported, AR does an immediate inspection. Finally, through its ambient program, AR also conducts periodic sampling from a series of sampling check points along water bodies, both selectively for pollution-prone water bodies and according to predefined annual programs. Local environmental protection agencies also carry out some limited water monitoring.

Water charges exist in Romania and consist of prices for direct consumption (water as a "good") and tariffs for discharges (water as a "service"). They were introduced at the start of 1991 and rates are indexed quarterly. There are separate national raw prices based on type of water body (surface, subterrainian, Danube) and category of user, with industry paying more than agriculture, and agriculture paying more than households. With little relationship to location-specific or temporal characteristics, however, this system does not accurately signal differences in water scarcity to economic agents. As a result, water-intensive activities may be undertaken in (socially) high-cost zones, though in principle AR may reject a construction permit request for such an activity. For the most part, however, plant location decisions under communism were not based on economic considerations. Water prices are also very low: rates per thousand cubic meters in 1996 for industrial users were 23,755 lei (US$4) from rivers, 2,851 lei (US$0.47) from the Danube, and 29,240 (US$5) from underground sources. Penalties of two to six times normal rates can be levied for abstractions *above* permitted limits, with the multiplier depending on the amount of the infraction and whether it occurred during a period of restricted consumption.

There are also charges for effluent discharges into water bodies. This charge system comprises two components, a *tariff* for within-permitted discharge concentrations and a *penalty* (over and above the tariff) for above-permitted discharge concentrations. In 1996, for example, tariffs were levied only on two contaminants: a 7,850 lei/ton charged for suspended solids and a 31,750 lei/ton (US$5.30) charge for BODs.

The penalty depends on both the volume of wastewater emitted and the *difference* between actual and permitted concentrations. For the *i*th pollutant, the formula used is $P_i = (C_i - C_i^*) V R_i$ where P_i is the total penalty assessed on the *i*th pollutant, C_i and C_i^* are respectively the actual and permitted concentrations of *i*th pollutant, V is the annual volume of wastewater discharged, and R_i is the rate for discharging the *i*th pollutant. In theory, for repeat offenders penalties are doubled each year until concentration standards are met.

Penalties are levied on twenty substances divided into two general categories. The first group (containing, e.g., nitrates, BODs, chlorine, cadmium,) is for those for which allowable levels are established to meet concentration standards. The second group (containing, e.g., mercury, persistent pesticides, radioactive residues, and carcinogens) is made up of substances for which no discharges are permitted and C_i^* is zero. Rates are lower for the first group of pollutants (BODs at $US4.90 per metric tonne in 1995) than for the second group (mercury at X US$13,000 per metric tonne in 1995).

3. THE STYLIZED FACTS IN THE WATER SECTOR

In spite of their low levels, revenue collection from water prices and discharge tariffs is a serious problem. Penalties assessed for effluent discharges and raw water abstractions *above* permitted limits in 1996 were 2.96 billion lei (US$1.5 million), yielding collections of 482 million lei. Worse, while revenues assessed in real terms were 240 percent those assessed in 1993, the collection rate has fallen from 24 percent in 1993 to 16 percent in 1996. Regarding water prices, while in 1996 AR regulated 5,000 industrial permit holders, it also was owed arrears from 3,000 enterprises.[5] Nevertheless, only three enterprises have been closed since 1991 due to water infractions.[6]

[5] The comparability of these two figures is in doubt since it is not clear whether the latter includes users without valid permits while the former comprises only permit holders. Information from personal discussions with AR officials.

[6] Information from personal discussions with AR officials.

This relatively lax enforcement is perhaps not surprising. At least until recently, governments across all ministries have had an implicit "take-it-easy" approach on enterprises, many of which were prohibited from borrowing and subject to other uneconomic restrictions. This has led to the authorities' inability to impose penalties or set prices for environmental goods and services at economic levels to achieve acceptable emissions, and to enterprises' indifference to operating with a valid permits. Therefore, two complementary approaches have also been taken, investment co-financing and compliance schedules.

The favored instrument of the government has been to augment the permit system with environmental abatement investment co-financing to stimulate enterprises to fulfill permit requirements. In 1994, for example, the national treasury provided the majority of financing. In the country's 1996 National Environmental Action Plan, the budget's share of investment fell to 45 percent of all investments compared to 58 percent in 1994 (see MAPPM, 1995). Under the 1997 FESAL agreement, this mechanism is not likely to continue, with the burden being shifted onto economic agents themselves as the enterprises are privatized.

While the concept of compliance schedules was developed to create feasible plans for polluters to reach compliance, in practice they have been used in the water sector to work with the enterprises to simply improve their performance. As such, it is an open question for analysis as to whether their use has actually slowed down full compliance.

With the hope of increasing its collections of water charges, MAPPM implemented a phase-in program for payments of assessed penalties. It was announced that for 1991, 25 percent of the assessed penalty must be paid, 50 percent of what was assessed in 1992 should be paid, 75 percent in 1993, and 100 percent from 1994 onwards. Starting in 1996, fines owed must double each year until individual standards are met. Unfortunately, the schedule was not indexed for changes in prices and inflation averaged 175% per year during the period 1991 to 1996. Debts from early in the phase-in period were therefore highly discounted. In real terms the pressure on enterprises actually fell over time up until 1995 and only after the period of forgiveness ended did real penalty rates increase.

These broad impressions can be deepened by looking at two datasets. The first is a firm-level survey for 1996 created for this paper and comprises a random sample of 81, above-average[7], industrial, water users possessing or in the process of receiving a water permit. The second is based on river basin-level data routinely collected by AR from which we have taken the years 1993-1996. Bivariate correlations of these data tell a consistent, if surprising story leading to a set of stylized facts.[8]

Physically, water pollution and abstraction were unrelated to whether the enterprise was located in a big or small town (though smaller-town enterprises used older technologies). The greater the share of state ownership in an enterprise, the more likely it had a water purification station. While bigger enterprises abstracted and discharged more, concentrations of discharges were unrelated to enterprise size.[9]

The penalty picture for abstraction was unexpected: no penalties were issued for excess abstraction for any enterprise in the sample. There simply was no above-permitted abstraction; in spite of the regulators' claims, the abundance of raw water was such that water allocations were not binding constraints for enterprises. This view is reinforced below when enterprise investment patterns are discussed.

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7 Average consumption nationally for permitted industrial users was 25 m^3/hr.

8 We use the arbitrary cut-off of less than 0.20 as the absolute value of the correlation coefficient to describe two variables as related or not.

9 This paragraph's results may be due to our sampling of only *above*--average water-consuming firms.

Regarding penalty collection rates, the greater the number (as well as average and total value) of penalties assessed, the lower was the enterprise's penalty payment rate.[10] Examining their ability to pay, enterprises with higher (gross) profits had fewer penalties (in number) but a higher total value of penalties assessed. The number and average size of penalties were unrelated, however, to the profit *rate*. Looking at the relationship between penalties to inspections, the number of penalties was positively related to the number of unannouced inspections but not related to routine or accidential inspections. Total penalties assessed were related positively to both routine and unannouced inspections, but not to accidential inspections. Penalties paid, however, were positively correlated to accidental inspections while *not* related to routine and unannouced inspections. Thus, while most penalties were issued as a result of unannouced inspections, payment of these were generally ignored while only inspections as a result of accidents resulted in a fine actually being paid. In fact, the greater the number of unannouced inspections, the lower was the enterprise's penalty payment rate.[11] Regarding regulatory control strategies, the probability of being inspected was not related to the enterprise's location. The number of total inspections had no relation to the economic size (e.g., number of employees, revenues, equity) of the enterprise nor its amount of abstraction. Finally, the greater the degree of state ownership (versus domestic private, or foreign), the greater the probability of routine and of unannounced inspection and the higher the value of total and average penalties; the opposite was true the more ownership was domestic private.

Before continuing, we may draw two important conclusions regarding penalties, inspections, and collections. First, there is a basic simultaneity between compliance and enforcement which needs to be disentangled to properly understand agency incentives. Second, the only way to understand the regulator's inspection program is to see that only unplanned inspections and "accidental" inspections directly reflect non-compliance at the enterprise while routine inspections, established by bureaucratic inertia based on the number in the previous year and only weakly as a result of the other types of inspections, represent the enforcement stance of AR. These key insights allow the detailed econometric work below to be developed.

Regarding the investment and finance picture, the level of investment in water abatement was unrelated to the size of enterprise profits, equity, or turnover. State budget subsidies for water abatement investment were negatively related to enterprise profits, to whether it exported and had regular foreign contacts, and to whether the enterprise engaged in water pre-treatment. Higher capacity utilization was related to higher concentrations in discharges and, therefore not surprisingly, related to higher levels of water investment, particularly investment for improving water quality. Curiously, higher capacity utilization was also associated with higher levels of investment subsidies and less interaction with the foreign sector.

Regarding public participation, a quarter of the enterprises in the sample experienced some public pressure. Most was related to pollution, not to excess abstraction — perhaps not surprising given that in truth raw water was not scarce.[12] This pressure was more (less) likely to be on an enterprise, the greater the share of domestic private (of state) ownership. This is odd considering that the sample indicated that the higher the state ownership share, the higher were the pollution penalties.

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[10] Keep in mind that the "penalty" is really just the second component of the pollution charge representing the price for above-permitted discharges.

[11] The data itself generally indicate that if an enterprise paid any amount of the assessed penalty, it paid the full amount; unfortunately, about half the fined enterprises chose to pay zero.

[12] This is not as obvious as it may seem considering that most households in Romania do not have water 24 hours a day. The paradox is resolved by noting that municipal systems have 60-percent loss rates and pumps are turned off to reduce energy bills.

Those firms with compliance schedules in force were much more likely to invest in abatement (though only financed through own funds) but such investment was related to water quality only (the compliance schedule being uncorrelated to water quantity investment). While the existence of a compliance schedule was independent of the penalty collection rate for a firm (the latter, perhaps, being a measure of the desire to comply), it was more likely for firms which experienced incidents leading to accidental inspections to have compliance schedules. Interestingly, while compliance schedules were also to be found more readily the higher the amount of penalties actually paid, they were *less* likely to be found the higher were *assessed* penalties. This suggests that regulators have succeeded in negotiating compliance schedules as a *quid pro quo* for leniency on penalty collection. Finally, compliance schedules were more likely to be found at firms with lower average penalties and a higher foreign share of ownership; this probably reflects the fact that minor problems (as suggested by the smaller penalty) are cheaper to fix, thereby facilitating the acceptance of a compliance schedule and that foreign investors have more money and are more interested in quickly improving their environmental image.

Looking across the eleven river basins in aggregate from 1993-6, a similar picture emerges regarding penalty and collections rates and enforcement. First, average penalties and collection rates over the period were positively correlated. This suggests that because returns to evasion are increasing in the value of penalties, higher penalties tend to reduce collections; smaller penalties therefore appear to be easier to collect.

In general, greater abundance of water resources was highly correlated to the number of penalties issued (0.68) and to the value of penalties paid (0.49) but, curiously, less so for the value of penalties assessed (0.28). The number of inspections was unrelated to the value of penalties assessed by somewhat correlated (0.27) to the value of penalties paid. The average penalty assessed by basin increased the *fewer* the number of users and amount of water resources per inspector, suggesting that increasing AR's financial and human resources would improve enforcement. While the number of users and amount of water resources had no effect on collection rates, the latter did increase the fewer were the resources per user. This complements the related finding on average penalties and suggests that as water scarcity increases, the user community does accept and take regulatory enforcement more seriously.

These river basin-level correlations aggregated over a tumultuous four-year period, however, hide some important temporal changes. First, while over the period 1993-1995 the collection rate and average penalty size fluctuated between -0.37 and -0.50, it fell to zero in 1996. Second, the correlations between the number of inspections, on the one hand, and the scarcity of water resources and the number of penalties, on the other, fall continuously and drastically from a high of 0.67 and 0.69 in 1993, respectively, down to a low of 0.18 and 0.17 in 1996. Furthermore, the correlation between users per inspector and the average penalty assessed fell from 0.67 to 0.36 over this period. Worse, regression analysis yielded a *negative* growth rate of inspection efficiency (number of penalties per inspection) of -33 percent over this period.[13] Since the number of inspections increased fifty percent over this period but staffing remained relatively constant, this is clear evidence for inspection quality being sacrificed for quantity as enforcement resources are squeezed during the transition period.

This plethora of stylized correlations, while intriguing, is far from definitive, primarily due to the extensive simultaneity and endogeneity of the various characteristics examined. More careful model-based econometrics is, therefore, required.

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[13] The log of the inspection efficiency was regressed on time (with t -stat.=-3.1, adjusted R^2 =0.69 and n=41) using the dummy variable absorption technique with Huber standard errors as described later in this paper.

4. THE MODEL

We now investigate the stylized facts presented above in three steps. First, we develop a theoretical model of the enforcement game between the enterprise and AR. This model is then used to disentangle the relationship between an enterprise's level of compliance and AR's level of control and enforcement. Finally, we use this information to examine the role of economic instruments and command and control to influence the enterprise's investment response to the regulatory regime.

The decision facing the enterprise in the short term is how intensively to use the water resources — even if it means exceeding permitted levels — given the costs for doing so. The "cost" may be directly financial due to an economic instrument or indirect through the imposition of additional regulatory oversight measures. A simple way to present this decision is to consider the enterprise as using water services, W, as its only production input and to assume that AR has previously allocated the enterprise a maximum amount of it, W_o, as reflected in the enterprise's operating permit. W may indicate quality or quantity, i.e., W may be considered a measure of abstraction or of pollutant discharge. We further simplify the presentation by assuming that the expected costs of using water services below permitted levels are zero and those above it are $P(W-W_o)\,\rho(N)$, where P(.) is the penalty for exceeding permitted levels with $P'>0$, $P''>0$ so that each additional amount in excess of permitted levels is relatively more heavily penalized, $\rho(N)$ is the combined probability that the infraction is discovered, the penalty assessed, and sum paid with $\rho'>0$, and N is the number of inspections by AR. Thus, the penalty collection rate is captured by ρ.

Letting the enterprise's production function and output price be $Q(W)$ and q, respectively, its decision problem is

$$\max_W \;\{\, qQ(W) - P(W-W_o\,)\,\rho(N) \,\} \tag{1}$$

and has as a first-order condition for $W^* > W_o$ of

$$\Omega \equiv qQ'(W) - P'(W-W_o\,)\,\rho(N) = 0 \tag{2}$$

Thus, since $d\Omega/dN = -P'\rho' < 0$ and $d\Omega/dW < 0$ for profit maximization then

$$dW^*/dN = (d\Omega/dN\,) \,/\, (-d\Omega/dW) \;< 0 \tag{3}$$

where W^* is the profit-maximizing level of water services. Thus, as one would expect, increasing the number of inspections tends to decrease the degree of excess water service use.

The decision facing AR in the short term is how to allocate the N number of inspections it is capable of doing per period across the regulated community of $i=1,\ldots,N_E$ enterprises so as to minimize the expected damages, $D_i\,\sigma_i$, from water services in excess of permitted levels where D_i are damages, if discovered and $\sigma(D_i\,,\,N_i)$ is the probability of discovery. This decision requires setting a number, N_i of inspections for each enterprise i. For simplicity we assume that each enterprise receives its water services from a different water body in the basin so that we may write the decision problem for AR as:

$$\min_{\{N\}} \;\{\, \Sigma D(W^i - W^i_o\,)\;\; \sigma(N_i\,, W^i - W^i_o\,, S, N_E) \,\} \qquad \text{s.t.} \;\; \Sigma N_i \;\le\; N \tag{4}$$

Here, S may be considered a vector of variables capturing the stress on or demand for the resource and N_E is the number of enterprises which the AR must inspect. The reason both N_i and N_E appear is that the more enterprises a given number of inspectors are responsible for, the shorter or less thorough is an inspection. The first order condition is:

$$\Psi \equiv D\,(W^i - W^i{}_o)\;\; \sigma'(N_i,\, W^i - W^i{}_o) \;-\; \lambda = 0 \tag{5}$$

where λ is the LaGrange multiplier.

Note that there is a relationship between σ and ρ:

$$\rho(N_i,\, W^i - W^i{}_o) = \sigma(N_i,\, W^i - W^i{}_o)\;\; \theta \tag{6}$$

where θ is the probability that a penalty is actually applied or applied in full; as will be seen in the following section θ will differ, depending on the strength on the enforcement regime in place in a given river basin.

The equations $\Omega(N_i, W_i) = 0$ and $\Psi(N_i, W_i) = 0$ may be used to develop reaction functions. Guaranteed through the fulfillment of the second order conditions, a stable (convergent) equilibrium is ensured if

$$(\mathrm{d}W/\mathrm{d}N)|_{\Omega} \;>\; (\mathrm{d}W/\mathrm{d}N)|_{\Psi} \tag{7}$$

Reaction functions satisfying these conditions are illustrated in Figure 1.

5. ANALYTIC RESULTS

It is clear from the above discussion that understanding what stimulates environmental investment requires disentangling the compliance response to a level of enforcement from the enforcement response to a level of compliance. This is done in section 5.1 and then applied to economic instruments, investment, privatization, perverse responses, and collection problems in the subsections that follow.

5.1 Compliance and Enforcement

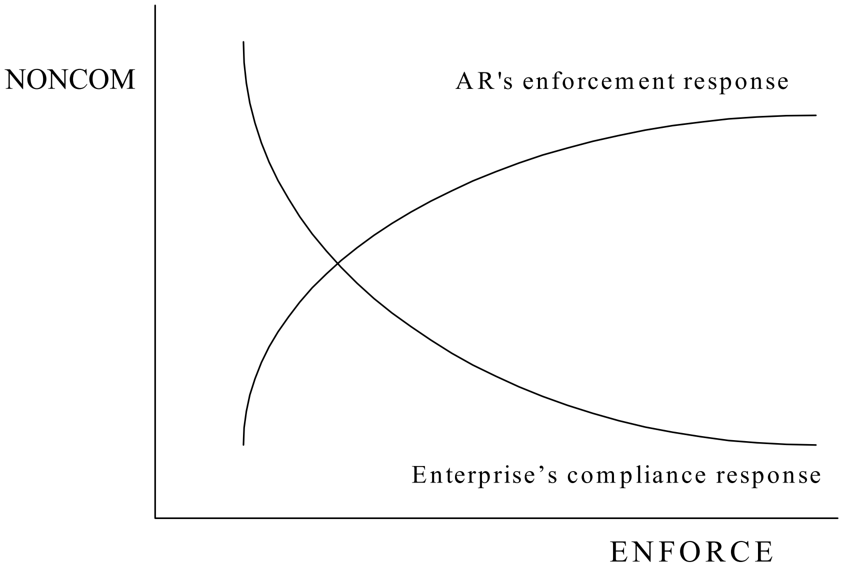
Based on the theoretical model above and using the two data sets described in section 3 the following simultaneous equations econometric model was specified:

$$\mathrm{ENFORCE}_{ib} = \mathrm{F}[\mathrm{E}(\mathrm{NONCOM}_{ib}),\, \mathrm{ARCAP}_b] \tag{8}$$

$$\mathrm{NONCOM}_{ib} = \mathrm{G}[\mathrm{E}(\mathrm{ENFORCE}_{ib}),\, \mathrm{POLCHRG}_b] \tag{9}$$

where F and G are functions to be specified and estimated, "E" is the expectations operator, *i* and *b* index the enterprise and the river basin, and NONCOM_{ib}, $\mathrm{ENFORCE}_{ib}$, and $\mathrm{POLCHRG}_b$ are, respectively, the enterprise's level of compliance with its permit, AR's degree of enforcement at an enterprise, and the pollution charge for exceeding permitted (quantity and quality) levels in each river basin. Considering the ENFORCE equation, theory predicts that an enterprise would be submitted to a stricter enforcement regime, the worse is its expected compliance, (the "enforcement curve" is upward-sloping) and the greater is the AR's capacity for enforcement. Considering the NONCOM equation, theory predicts an enterprise's compliance improves the higher is the expected penalty and the stricter is the expected enforcement (the "non-compliance curve" is downward-sloping). The system is illustrated in Figure 1.

Figure 1. Disentangling the Relationship Between Compliance and Enforcement



5.1.1 The Variables

The key to estimating this system were a number of insights regarding good overall measures of the variables involved. First, as revealed in section 3, AR's enforcement (ENFORCE) regime could be measured by the number of routine inspections set for each enterprise. This is because these are in fact pre-programmed based on expected enterprise performance and the amount of human resources available for inspection at the AR. Second, the number of unannounced and "accidental" inspections reflected regulatory responses to compliance lapses at an enterprise and, thereby, reflect well an enterprise's actual compliance (NONCOM).[14] For a measure of AR capacity, ARCAP, the total number of inspections made was used. It is this number which had to be allocated in the theoretical model as well. Finally, since there is a single national pollution charge, if this were used then there would have been no variance for the variable in question. Therefore, we constructed the variable POLCHRG to be $P^E = \theta P^N$ where θ as before is the conditional probability that a charge is collected, given the compliance lapse is discovered and charged. Thus, while P^N is invariant nationally, P^E varies approximately by river basin.

5.1.2 The Estimation

Noting that this system is exactly identified, its reduced form may be solved and then estimated using indirect least squares (ILS) by individually regressing:

$$\text{ENFORCE}_{ib} = a + b\,\text{POLCHRG}_b + c\,\text{ARCAP}_b + u_{ib} \qquad (10)$$

$$\text{NONCOM}_{ib} = d + e\,\text{POLCHRG}_b + f\,\text{ARCAP}_b + v_{ib} \qquad (11)$$

where a, b, c, d, e, and f are the parameters to be estimated and u_{ib} and v_{ib} are the standard, i.i.d. least-squares error terms. The structural parameters of the system could then be retreived using these

[14] This is well borne out by the fact that the correlation between these sorts of inspections and concentrations of suspended solids and BODs were 0.92 and 0.88, respectively.

parameters. In fact, the alternative used here was to recognize the equivalence between ILS and the standard two-stage instrumental variables approach. What is particularly appropriate about this equivalence is that the instruments for ENFORCE and NONCOM (denoted below with the "IV" superscript) may be interpretted economically as the expected values of each variable. The results of the estimation are:

$$\underset{}{ENFORCE_{ib}} = \underset{(0.17)}{0.340} + \underset{(2.6)}{0.941}\, NONCOM^{IV}_{ib} + \underset{(4.1)}{0.003}\, ARCAP_b + u_i, \quad \text{Adj. } R^2 = 0.17 \qquad (12)$$

$$NONCOM_{ib} = \underset{(4.3)}{18.5} - \underset{(-3.3)}{1.53}\, ENFORCE^{IV}_{ib} - \underset{(-3.5)}{13.2}\, POLCHRG_b + v_i, \quad \text{Adj. } R^2 = 0.12 \qquad (13)$$

where the *t*-statistics are in parentheses and the number of observations were 81 in each case. As is seen, the signs are as the model's theory predicts and illustrated in Figure 1.

5.2 Economic Instruments and Investment

As shown above, the level of compliance of an enterprise is affected both by the signal of the pollution charge and AR's enforcement behavior. It is the aim of environmental policy that such effects should lead to enterprise investment. In this section, we examine whether any investment response can be detected and whether another economic instrument, the subsidy, which governments have often used in the past, has any stimulative effect.

5.2.1 The Model

The reduced form relationship considered is based on the hypotheses that the level of an enterprise's investment (in 1996) was related to its industrial sector, the degree it used water goods and services, its financial ability to invest, its expected level of non-compliance, and any pre-existing investment program commitments.

5.2.2 The Variables

The variable to be determined is the enterprise's investment in water quality in 1996 (WINV). The predicted values of NONCOM from section 4 were used to measure expected non-compliance. We use the enterprise's total discharge (DISCH) as a proxy for water services used.[15] The enterprise's use of water *qua* good is taken as the amount of water consumed (CONS), equal to abstraction minus discharges. The enterprise's financial ability was measured by gross profits over turnover (PROF). Finally, past environmental financing commitments was taken as the sum in 1996 Romanian lei of investment in water quality in 1994 and 1995 (L_WINV).

5.2.3 The Estimation

Investment is obviously highly linked to the particular industrial sector. Ideally a dummy variable would be appropriate for each sector. Unfortunately, we only have 81 observations available. Therefore, we have employed a linear regression method which "absorbs" these sectoral dummies into one categorical factor but which produces robust standard errors based on Huber's formula for individual-level data, thereby allowing consistent standard errors to be estimated even if there is heteroscedasticity or clustered

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[15] The reason that a measure of pollutant discharges was not used here is that these are already picked up in the noncompliance variable, NONCOM.

sampling.[16] The main drawback of this approach is that the individual coefficients of the dummy variables cannot be recovered. The estimation results are shown in Table 1.

The regression suggests that the effect of expected non-compliance leads to greater investment in water quality. The amount of this investment was greater, the greater was past investment. Profitability (PROF) here indicates an ability to pay and, as such, also has a positive effect on WINV. The negative coefficient on water discharges supports the hypothesis tested below that more polluting enterprises dillute their waste streams, thereby lowering their average concentrations and subsequent requirements in water quality investment. Consumption, on the other hand is costly and triggers a positive investment response.

Without providing all the regression statistics, an identical regression was run including an additional term to capture the size of budget subsidies in 1996 SUBS. The results are the same as above with coefficients being even slightly "more" significant, especially regarding NONCOM. However, though negative, SUBS was not statistically significant (*t*-statistic of -0.365). This suggests that subsidies had probably no stimulative effect in generating investment (and, if the sign is right, even a pacifying effect).

Table 1 Water Investment Regression with Huber Standard Errors

Variable	*Coefficient*	*t-statistic*
L_WINV	1.046705	10.589
CONS	16.20723	4.252
DISCH	-46.31995	-5.443
PROF	895215.8	3.142
NONCOM (predicted)	36318.18	1.742
Constant	-57080.24	-0.521
Industrial dummies	Absorbed (18 categories)	
Dependent variable: WINV	Number of obs = 76	
Grouping variable: river basin	Adjusted R^2 = 0.8456	

5.3 Privatization

Romania, like most other countries in Eastern Europe, is undergoing a massive privatization of its industrial enterprises. This raises the obvious question about whether the ownership of an enterprise has been a missing factor in the above analysis. As argued at the outset of this paper, privatization should have at least two effects in theory. First, the imposition of a "hard" budget constraint should cause management to have a more pronounced response to the price incentives of economic instruments. Second, the new owners of privatized enterprises often have made additional investment commitments and have brought additonal sources of capital (as well as the ability to borrow it). While this may increase their ability to pay economic instruments on the one hand, it also may make them sitting targets for the regulatory agencies whose compliance demands have historically been tailored to their perceptions of an enterprise's financial resources. The profit motive brings with it pluses and minuses. On the plus side, it causes enterprises to reduce all forms of waste, including waste in the form of pollutants in water discharges (which may even be potentially valuable if recovered). On the minus side, however, it leads enterprises to use relatively intensively those inputs whose relative prices are lowest. Since weak enforcement serves to reduce the perceived "price" of environmental waste assimilation services, the profit motive could

[16] The description of this technique here draws on Stata(1985) and was first developed by Huber(1967) as well as independently by White (1980).

encourage privatized enterprise to take advantage of weak enforcement, thereby stretching (or even ignoring) regulatory limits.

What is different about a privatized firm? Table 2 indicates the answer for the companies sampled for the present study. Here, we look at firm characteristics *after* accounting for the likely fact that the state's share of ownership (SHRSTAT) is probably sector-specific. We see that enterprises with older vintage equipment (VINTAGE) and lower capacity utilization (CAP_U) tend to have greater state ownership. These are efficiency (as well as pollution-generating) measures. However surprisingly, greater numbers of employees (NUMEMP) or lower profitability (PROFITY) were *not* the mark of greater state ownership in this sample.[17]

We may now examine the effect of accounting for the share of state ownership on enterprise compliance and environmental performance. First, we examine how the compliance-enforcement relationship is affected by the level of state ownership. This can be done by re-estimating the model in section 5.1 and including the share of state ownership, (SHRSTAT) as an explanatory variable.

Table 2 Characteristics of Higher State Ownership Share (SHRSTAT) Using Regression with Huber Standard Errors

Variable	*Coefficient*	*t-statistic*
VINTAGE	0.0143	4.366
PROFITY	0.1212	0.544
NUMEMP	7.94e-07	0.353
CAP_U	-0.1953	-1.667*
Constant	0.4658	4.738
Industrial dummies	Absorbed (18 categories)	
Dependent variable: SHRSTAT	Number of obs = 76	
Grouping variable: river basin	R^2 = 0.5082	
	Adj R^2 = 0.3169	

*Significant at the 90-percent level.

[17] This illustrates the importance of using the Huber regression method. Without accounting for the state's propensity to be in certain sectors, the statistical significance results (with *t*-statistics in parentheses) are reversed with profitability becoming so and capacity utilization no longer so:

$$\underset{}{SHRSTAT_i} = \underset{(5.24)}{0.59} + \underset{(2.03)}{0.007}\ VINTAGE_i - \underset{(-1.65)}{0.222}\ PROFITY_i - \underset{(-0.948)}{0.120}\ CAP\_U_i + u_i, \quad \text{Adj. } R^2=0.12, \text{ Num. Ob.}=76$$

$$ENFORCE_{ib} = 1.372 + 0.759\ NONCOM^{IV}_{i\,b} + 0.003\ ARCAP_b + u_i, \quad Adj.\ R^2 = 0.15 \qquad (14)$$
$$\qquad (0.70) \quad (2.33) \qquad\qquad (3.98)$$

$$NONCOM_{ib} = 16.0 - 1.49\ ENFORCE^{IV}_{ib} - 12.79\ POLCRHG_b + 3.11\ SHRSTAT_i + v_i, \ Adj.\ R^2 = 0.12 \ (15)$$
$$\qquad (3.5) \quad (-3.2) \qquad\qquad (-3.5) \qquad\qquad (1.33)$$

where the number of observations were 81 and the *t*-statistics are in parentheses. As is seen, none of the signs of the variables' coefficients change though there is a minimal fall in their magnitudes. Statistically significant at the 81 percent level, the positive sign on SHRSTAT suggests that non-compliance is higher, the greater is the level of state ownership.

This finding is strengthened when we look at how the performance of enterprises with greater state ownership influences the assessed penalty component of the pollution charge. Again using the Huber regression method to account for the possibility of state pre-selection into more polluting sectors, the following equation suggests how the average penalty assessed (AVGPEN) is influenced by the ownership structure of the firm (SHRSTAT):

$$AVGPEN_i = 242 + 3067\ SHRSTAT_i + h\ \Sigma_i^{N-1}\ d_i\ D_i\ + u_i \quad Adj.\ R^2 = 0.57, \ No.\ Obs.=25 \qquad (16)$$
$$\qquad (0.21) \quad (1.88) \qquad\qquad (absorbed)$$

Statistically significant at the 90-percent level, this equation helps to strengthen the earlier results by indicating that higher levels of state ownership tend to lead to higher average penalties, *ceteris paribus*.[18] A third interaction related to enterprise ownership will be shown below when the issue of collection rates is discussed.

5.4 Perverse Responses: Dillution Effects

As is always the case with government intervention, even of the economic instruments type, it can lead to perverse incentives and unwanted side-effect behavior. A case and point is with the charging for pollutant discharges. By diluting effluent streams, the total tariff charges (or the threat of command and control oversight) can be in theory reduced. In Romania, though pollutant concentrations are monitored, total payment is based on the number of hours of factory operation times a technical coefficient of discharge per hour of operation times the monitored concentration. Thus, by exceeding the technical discharge rate, the enterprise can reduce the level of the monitored concentration. The only additional cost for this sort of defensive action is to increase abstraction costs.

To test for this possibility, the following simple short-run dillution decision model is proposed.[19] Given a level of (assumed exogenous) water consumption, Q^c, and pollutant generated, *L*, the enterprise chooses a level of discharge, *H,* which minimizes the combined costs of abstraction, *A* (whose water price is *w*), plus pollution tariffs (assessed at a rate of *t*) which are calculated based on monitored concentration, *L/H*, in excess of permitted levels, *c** times the technically computed discharge, H^T :

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[18] The sample for this regression was restricted to enterprises which were assessed penalties. When rerun with the full sample (setting AVGPEN=0 when no penalty was assessed) the regression resulted in, not surprisingly, a smaller coefficient of 715 for SHRSTAT though at a lower level of significance (*t*-statistic of 1.5). A simple regression of AVGPEN on SHRSTAT ignoring industry dummies but on the full 81-observation sample, resulted in a SHRSTAT coefficient of 2570 and a *t*-statistic of 1.77.

[19] We say "short-run" because the state of the transition means that the alternative to dillution, namely production process changes, have not been carried out yet.

$$\min_{\{H\}} \quad \{ H^T[(L/H) - c^*]t + (H + Q^c)w \} \tag{17}$$

Solving this minimization problem for H and putting the result into the abstraction identity, $A = Q^c + H$ leads to the equation:

$$A = Q^c + (H^T Lt/w)^{1/2} \tag{18}$$

This equation may be estimated using water consumption (WCONS) for Q^c, suspended solids (SUSSOL) for L and water abstraction (ABS) for A. As before, since all enterprises face the same tariff rates, we used the concept of expected tariff payment (TARIFF) where the national tariff has been multiplied by the enterprise's rate of tariff payment. The results, again using the Huber regression method with industry dummies, B_i, are:

$$\underset{(-3.71)}{\mathrm{ABS_i} = -4018} + \underset{(7.52)}{2.45\ \mathrm{WCONS_i}} + \underset{(3.69)}{5888\ \mathrm{TARIFF_i}} + \underset{(18.9)}{7.71\ \mathrm{SUSSOL_i}} + \underset{\text{(absorbed)}}{h\ \Sigma_i^{N-1} b_i B_i} + u_i \tag{19}$$

Adjusted $R^2 = 0.91$, N=25

Inspection reveals that all the variables have the signs implied by equation (18). The estimated equation, therefore, suggests that, once (exogenous) water consumption is accounted for, an enterprise's abstraction is influenced by the degree of pollutants it discharges, the more so the higher the (firm-specific) tariff rate.[20] As predicted by the model, since higher charges lead to greater abstraction, the pollution charges have created a perverse incentive to abstract water in excess of what is needed to meet permit concentration requirements.

5.5 Collection Rates and Inspections

Clearly, in order for economic instruments to have an incentive effect, not only do they need to be raised to economic levels, but the sums assessed must also be collected. As presented in section 3, however, collection rates are very poor. This calls into question the efficacy of further raising pollution rates. In this section, we look at a number of contributing factors at both the basin- and the enterprise-level. These include ability-to-pay issues, ownership, and the strength of regulatory enforcement.

At the basin level, we examine whether the average size of the assessed pollution charge influences the collection rate of the AR branch, once other factors are accounted for. Two key factors include the state of the economy (as measured by real GDP growth rate, RGDPR) to capture the general ability to pay of enterprises in the basin and the regulatory load of AR in the basin (as proxied by the amount of water resources per number of inspectors, BREGLOAD) to capture the strength of regulatory enforcement. We would expect that basins with higher average charges would lead to lower rates of repayment. Using the following reduced form equation to regress river basin collection rates (BCOLRATE) on the average pollution charge (BAVCHARG) in the basin (with t-statistics in parentheses), we see that this is borne out:[21]

$$\ln(\mathrm{BCOLRATE_{bt}}) = \underset{(3.26)}{9.79} - \underset{(-5.06)}{1.04^*\ln(\mathrm{BAVCHARG_{bt}})} - \underset{(-2.95)}{0.99^*\ln(\mathrm{BREGLOAD_{bt}})} + \underset{(1.93)}{33.8^*\mathrm{RGDPR_t}} + u_{bt} \tag{20}$$

n=30, Adj. R^2 =0.46

[20] The model estimation did not generate results when BODs were included instead of suspended solids.

[21] Recall that charges comprise two components, the "tariff" for below permitted levels and the "penalty" for above-permitted levels.

AR(1) parameter=0.55 (*t*-stat=4.17)

This relationship is estimated for the period 1993 to 1996 using the standard Cochrane-Orcutt iterative procedure for first-order autocorrelation correction. The results indicate that increases in the average charge are associated with lower collection rates *ceteris paribus*. Moreover, collection rates would improve if additional resources were allocated to enforcement and if the state of the economy were to improve.[22]

Turning to the enterprise level and accounting for regulatory load (proxied by REGLOAD, the ratio of enterprises per inspector) the following two regressions further illustrate the effect of higher pollution assessments in 1996 (POLBILL) on collection rates for enterprise *i* in basin *b*, the first equation taking into account ownership structure and the second profitability (PROFITY):[23]

$$COLRATE_{ib} = \underset{(4.17)}{1.93} - \underset{(-2.5)}{0.897}\ SHRSTAT_{ib} - \underset{(-2.45)}{0.002}\ REGLOAD_{ib} - \underset{(-1.73)}{2.11}\ POLBILL_{ib} + u_i, \qquad (21)$$

Adj. R^2=0.31, N=25

$$COLRATE_{ib} = \underset{(4.15)}{1.49} + \underset{(2.27)}{2.01}\ PROFITY_{ib} - \underset{(-2.86)}{0.003}\ REGLOAD_{b} - \underset{(-2.68)}{3.29}\ POLBILL_{ib} + u_i, \qquad (22)$$

Adj. R^2 = 0.33, N=25

These more micro-level relationships reinforce the basin-level insights above. First, the larger is the pollution charge bill, the lower is the tendency to pay in full. Second, the state of the economy effect on repayment in the basin-level regression probably reflects enterprise lack of ability to pay, as proxied here by profitability. Finally, we see that privatization will improve enterprise payments of pollution charges — regardless of profitabilty. While this in helpful in its own right, it portends another more important development. Since privatized enterprises will try to minimize input costs, the fact that they tend to pay more of the charges they are assessed indicates that they will be more responsive to existing (low) the pollution charge rates; thus, privatization should lead to reduced pollutant flows.

6. POLICY IMPLICATIONS

Based on the analysis above, a number of policy conclusions may be drawn. First, although pollution fees are extremely low and rarely assessed, they do have some value in signalling to enterprises when the authorities are fed up with the enterprise's low compliance. As such and probably only indirectly as a result, higher fee rates do seem to generate an improvement in compliance. On the other hand, enterprises acceptance to pay these fees falls, the higher is the overall fee bill. Still, it is possible to discern an effect

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[22] We wondered how far one could improve collections rates by adjusting the pollution charge. This was checked using the following regression (where Δ indicates the variable has been first-differenced):

$$\Delta BCOLRATE_b = \underset{(2.00)}{0.217} - \underset{(-4.32)}{0.659}*\Delta BAVCHARG_b - \underset{(-2.50)}{0.392}*(\Delta BAVCHARG_b)^2 + u_b, \quad n=33, \quad \text{Adj. } R^2 = 0.73$$

The negative sign on the squared term indicates that the collection rate cannot be increased indefinitely by lowering the size of penalties and that a revenue-maximing average penalty size exists.

[23] Recall that for the curent sample, profitability and state ownership share capture very different characteristics, with no correlation between the two.

of these fees on enterprise investment behavior, even after controlling for the level of water authority enforcement efforts.[24] Subsidies, on the other hand, were found to have no influence on water sector investment.

As suspected, privatization so far has had an influence on the use of water assimilation services and consumption. Since this paper has shown that enterprises with a lower private ownership share are assessed higher penalties, display lower compliance, and are less likely to pay the pollution fees assessed, privatization is likely to improve enterprise compliance in spite of the many forces mentioned in this paper which might encourage profit-maximizing firms to operate to the contrary.

As is true with any government interference in the market, pollution charges can generate perverse incentives if improperly implemented. In Romania we show that this is the case in the water sector. Enterprises apparently have an incentive to dilute their effluents in order to reduce pollution tariffs and additional regulatory oversight measures. However, at least in this case, a modified procedure involving the monitoring of discharge amounts (instead of using preset technical parameters) would correct the problem.

We ended our analysis by recognizing that it is the *expected* pollution charge which economic agents use to base their compliance decision on and that the expectation was related to the rate of collection of the pollution charges assessed. We therefore, examined the collection problem. We show that nonpayment of pollution charges is inversely related to the level of the assessment and that enterprise nonpayment is excaserbated, the more over-stretched is the enforcement agency and the weaker is the economy while it is ameliorated the more profitable are enterprises. Finally, regardless of profitability, greater state ownership increases nonpayment. As such, the lower is the enterprise's ability to pay and the higher is its assessed bill, the lower will be its rate of payment of charges that do get assessed. These results, however, point to solutions: enterprise privatization and greater financial resources to the regulatory authorities. Moreover, since privatized firms also seek to minimize input costs, the fact that they are more likely to pay their assessments corroborates our earlier result that they will also improve their environmental compliance.

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[24] While not developed in this paper, the data have helped resolve a long-standing dispute regarding water scarcity in Romania: no abstraction penalties were assessed, let alone collected. The reason? In spite of all the hype, water is so abundant that abstraction permit levels may be set so high so that no enterprise need exceed — never mind have to pay for — "excessive" (above-permitted) abstraction.

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