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# The Allocation of Environmental Liabilities in Central and Eastern Europe

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**Existing soil and groundwater contamination are likely to affect future industrial development and investment in Central and Eastern Europe, as large-scale pollution cleanup costs are potentially tied to industrial property transactions in that area of the world and the division of liability for these costs is uncertain. Determining how pollution cleanup costs should be allocated between governments and current or future property owners will not be easy. Retroactive liability is unlikely to be a desirable or a feasible means of assigning such costs for several reasons—one reason being its costly impact on the large number of thinly capitalized firms in the region. Publicly financed liability funds, by widely distributing cleanup costs, create a more desirable climate for foreign and domestic investment than does a U.S.-style system of retroactive liability, and will lead to a better prioritization of cleanup efforts. However, pooled fund programs should be operated on a short-term basis only, as they may reduce private incentives to invest in pollution reduction.**

Privatization and market reform in the economies of Central and Eastern Europe are occurring against a backdrop of severe environmental degradation left by decades of inadequate government attention to environmental conditions. The legacy of soil and groundwater pollution inherited by the new governments of Central and Eastern Europe not only creates direct health and ecological costs but is also likely to affect future industrial development and investment. The contentious development and expensive implementation of legal and regulatory approaches to mitigating environmental degradation in the United States and the European Economic Community (EEC) suggest that environmental problems in Central and Eastern Europe—where economies are much weaker, environmental problems much greater, and legal and regulatory institutions much less developed than in the West—will only be resolved at great economic and political cost.

In theory, an effective environmental liability system in Central and Eastern Europe will serve to deter the future generation of pollution by threatening polluters with liability costs arising from improper waste generation or disposal. However, a more immediate, practical

consequence of new liability rules is the assignment of responsibility for existing pollution. This assignment raises an important question—namely, how should the costs of removing or reducing existing pollution be allocated between governments and current or future property owners? The answer is complicated by the financial weakness of both governments and property owners in Central and Eastern Europe, the costs and uncertainty involved in the quantification of environmental risks, the political nature of liability reform, and the need to promote domestic and foreign investment.

While the costs of remediating existing pollution in the former Soviet bloc cannot be precisely estimated, they are clearly huge. The estimated cost of meeting EEC or U.S. environmental standards in Poland, for example, is as

*Determining how responsibility for the costs of remediating existing pollution should be allocated between governments and property owners is complicated by uncertainty regarding cleanup costs and potential liabilities; this uncertainty impedes domestic and foreign investment.*

high as $300 billion. There is great uncertainty regarding the costs of remediating existing pollution due to the lack of lending and insurance institutions familiar with risk assessment and to the virtual nonexistence of accounting, zoning, or regulatory requirements for documenting risk-generating processes or technologies. Large-scale pollution costs are thus potentially tied to transactions involving industrial property in Central and Eastern Europe.

Uncertainty regarding potential liabilities is exacerbated by the lack of established liability concepts, legal precedent, and consistent enforcement principles in Central and Eastern Europe. The formerly communist countries have no common-law traditions—such as those in the United States—that allow environmental claims based on concepts such as nuisance, trespass, negligence, or strict liability. Instead, they use a civil law approach that imposes damages almost exclusively in cases where there has been a violation of a government standard or regulation. A civil law, rather than a common law, definition and enforcement of liabilities presents an opportunity for governments to coordinate and achieve cost-effective resolutions to the cleanup of existing pollution. However, it also creates uncertainty for potential investors. Because such a system is defined neither by precedent nor by a consistent application of judicial principles, the scope and division of potential liabilities is unclear.

The unique environmental and institutional conditions in the countries of Central and Eastern Europe argue for liability approaches that may differ from those advocated in countries with more advanced legal systems, less pollution, and greater economic vitality. Given these unique conditions, the environmental liability systems established in Central and Eastern Europe should be influenced by two goals. First, in light of the need for economic growth, liability rules consistent with the promotion of privatization and foreign investment should be favored. Second, because Central and Eastern European governments lack the funds to pay the entire cost of cleaning up existing pollution, legal and regulatory policies should be designed to target public revenues toward the environmental hazards that pose the greatest threat.

To pursue these goals, liability initiatives in Central and Eastern Europe should distinguish between the timely and effective implementation of liability rules governing the creation of future

environmental risks, and the efficient cleanup of pollution generated in the past. These are entirely different issues. The first concerns the question of how to create incentives for future pollution reductions, while the second concerns the question of how to efficiently achieve a distributional goal—that is, how the costs arising from pollution created in the past should be borne. With respect to the latter, it can be easily argued that both moral and legal responsibility for existing pollution lies primarily with the former Soviet bloc governments themselves. The question of who should bear the costs of remediating existing site contamination is particularly important since it is likely to affect patterns of foreign and domestic investment, and clearly affects the value of initial asset endowments distributed in the process of privatization.

## The argument against strict and retroactive liability

One liability approach that might be instituted in Central and Eastern Europe is strict and retroactive environmental liability. This type of liability holds the current owner of a property fully liable for pollution cleanup and compensation costs, even when the pollution was generated by past owners or users of the property. While strict and retroactive liability strongly deters the future generation of pollution, its application in the United States has prompted debate over its inequitable allocation of responsibility for cleanup costs and its potentially adverse impact on property development.

Independent of judgments about its effects on pollution reduction and economic activity in the United States, strict and retroactive liability is unlikely to be desirable or even feasible in Central and Eastern Europe for several reasons. First, given the weak condition of the economies of Central and Eastern Europe—which is due in large part to capital scarcities—such liability could

In Copsa-Mica, Romania, the land that farmers tend is black from soot emitted by factories. Here, as elsewhere in Central and Eastern Europe, a precise technical—let alone legal—separation of responsibility for the costs of existing pollution and the costs of pollution being generated by new property owners may be unrealistic.

*Photo courtesy of Antonin Kratochvil/Dot Pictures*

but to the success of liability rules aimed at future pollution reduction. As in the West, environmental policies in Central and Eastern Europe will be derived and enforced in a political context, and their distributional impacts will largely determine their legislative and political success. The fact that liability rules have large distributional, and hence political, consequences can influence the evolution and enforcement of environmental pollution law. Because the profitability (or existence) of new enterprises is potentially threatened by strict and retroactive liability, resources will be directed at the political system to redistribute costs. One natural way to do this is to seek changes in the liability rules themselves. Given the political context in which liability laws are formulated, it follows that rules dealing with future liabilities should be separated from rules dealing with retroactive liabilities in order to enhance political acceptance of a tough prospective liability system. A more equitable distribution of the costs arising from existing pollution makes laws aimed at future pollution reduction more politically and economically sustainable.

*Strict and retroactive environmental liability is likely to be undesirable in Central and Eastern Europe, as it could force domestic producers into bankruptcy or asset liquidation; such liability is not likely to lead to an effective prioritization of cleanups but is likely to stifle foreign investment.*

impose costs high enough to force many domestic producers to declare bankruptcy or liquidate their assets. Given the magnitude of existing environmental hazards, the full internalization of costs based on a strict and retroactive application of liability might yield negative real asset values for a significant fraction of industrial properties. These consequences are inefficient, since bankruptcy and asset dissolution involve costs in the form of abandoned capital, lost firm-specific human capital, and reduced competition. In any event, shortages of capital and the tenuous financial position of newly privatized firms suggest that liability rules dependent on firms' ability to liquidate or otherwise free capital to compensate for environmental damages will be ineffective.

Second, a strict and retroactive liability system is not likely to lead to an effective prioritization of cleanups. Under such a system, only the most unpolluted properties would be sought for development, and resources would therefore be devoted to the cleanup of relatively unpolluted properties.

Third, a strict and retroactive liability system will likely stifle foreign investment, which is critical to the acquisition of skills, technology, and capital by Central and Eastern Europe. Foreign investors' concerns about retroactive liability derive from their experience with huge retroactive liability costs in domestic markets, the fact that their firms' capital is relatively available to be tapped in the event of liability actions, and the lack of political stability—and hence investor influence—in Central and Eastern Europe.

Fourth, the political and ethical "polluter pays" motivation for strict and retroactive liability does not in general apply in Central and Eastern Europe. Because former governments and managers of cooperatives are most to blame for existing pollution, there is little ethical justification for the new owners of privatized properties to be liable for the past sins of others.

Fifth, the distributional impact of strict and retroactive liability poses a threat not only to the success and timeliness of cleanups of existing pollution

From a practical standpoint, however, separating the costs of existing pollution from the costs of pollution being generated by new property owners is

difficult, since precise definitions and divisions of responsibility for pollution require costly risk assessment efforts. Even in the United States and EEC, an initial, noncomprehensive environmental audit can cost hundreds of thousands of dollars for a major industrial site. Because the risk assessment capabilities of Central and Eastern European governments and industries are greatly inferior to those of their counterparts in the West, it is unlikely that an accurate division of responsibility for pollution is possible at a reasonable social cost. When existing pollution is widespread but difficult to detect with conventional site assessment methods at the point when ownership of a property is transferred, and when advanced risk assessment technologies and expertise are in short supply, a precise technical—let alone legal—separation of responsibility for pollution cleanup may be unrealistic.

## Contractual mechanisms for allocating retroactive liability

Given uncertainties regarding the scale of and the liabilities implied by existing pollution, different contractual mechanisms to allocate liability may be needed to improve the efficiency of privatization and foreign investment decisions. The desirability of alternative contract forms is largely a function of the type of information available and the point in time at which information is acquired. With respect to the latter, assessment of liabilities may occur either ex ante, at the point of transaction, or ex post, following the transaction.

Knowledge of either responsibility for or the extent of pollution may be available to only one of the parties to a property transaction. For example, a government may have knowledge of existing pollution risks but choose not to reveal them prior to a transaction. On the other hand, if the government is unable to ascertain when pollution was generated and grants amnesty for

retroactive liability, an investor might inflate the value of risks he or she claims to have inherited at the point of sale.

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*One imperfect but potentially desirable way to distribute the costs of existing pollution while creating incentives for the reduction of future pollution generation is to provide relief from retroactive liability through the provision of government funds earmarked for cleanups.*

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In the unlikely event that both the buyer and the seller have complete knowledge of all the risks posed by pollution on a property, there are two primary contractual possibilities. One is for the seller (the government) to guarantee that no liability will be assessed for existing hazards. The other is for the government to impose strict retroactive liability on the buyer but discount the price of a property to account for the costs of such liability. The virtue of the latter approach is that the property transaction would be immune to "renegotiation" by the government. Therefore, subsequent disputes over which hazards did or did not exist at the point of sale would be avoided.

When the buyer cannot observe contamination of a property ex ante, he or she is purchasing an asset of unknown quality. Given this, an optimal contract requires insurance against levels of risk that differ from those revealed by the seller. Should the seller know that the property is clean, that person can simply guarantee to compensate the buyer for expenses resulting from any subsequently revealed contamination; alternatively, he or she can absolve the buyer of liability. If

contamination created before the sale can be separated from that created after the sale, an optimal contract would release the buyer from retroactive liability costs. Having done so, the asset price would reflect the property's value net of retroactive liabilities. When the buyer cannot observe contamination ex ante, retroactive liability for the buyer is clearly not desirable, since the costs of liability are not known at the point of sale and so cannot be accurately discounted from the asset price.

If pollution generated by the buyer cannot be separated from pollution existing at the point of sale, however, a liability amnesty would give the buyer a loophole to escape the costs of the pollution he or she generated. In this case, government assumption of liability may be inefficient. The conflict between buyer uncertainty over liability and the creation of loopholes by liability amnesties underscores the importance of environmental audits, which allow for an accurate separation of responsibility for pollution.

If a clear separation of responsibility is not practical, the question that remains is how to distribute the costs of existing pollution while creating incentives for the reduction of future pollution generation. An imperfect but potentially desirable approach is to provide relief from retroactive liability through the provision of government funds earmarked for cleanups. Two distinct forms of liability funds exist. One form is pooled funds, which provide public money for cleanups and compensation—money that would be provided by property owners in a Superfund-type liability system. The other form is the liability escrow account, in which a fraction of a property's purchase price is set aside and earmarked for cleanup costs defined at a later date. A crucial difference between the two funds is that escrow funds provide money to clean up pollution at one specific property, while pooled funds provide money for the cleanup of any number of properties.

## Pooled funds

Pooled funds, which are conceptually related to "no-fault" pollution insurance, have been instituted or proposed in several countries to deal with large-scale environmental risks. They can differ in terms of duration, limits on the nature and scale of costs covered, and criteria—such as compliance with regulatory standards—that must be met in order for property owners to be eligible for reimbursement of cleanup costs. In all cases, however, only a fraction of liabilities are borne by property owners, with the balance being borne by the pooled fund.

*Pooled funds, which provide public money for cleanups and compensation, widely distribute the costs of environmental cleanups and thus may represent the least economically disruptive mechanism for dealing with large retroactive liabilities.*

Pooled funds are contrary to the notion that the polluter should pay cleanup costs. However, the use of public moneys for cleanups in Central and Eastern European countries is more easily justified than in western countries, since decades of state ownership and central planning in the former imply that responsibility for existing pollution lies largely with the governments of Central and Eastern Europe.

Because they widely distribute the costs of environmental cleanups, pooled funds may represent the least economically disruptive mechanism for dealing with large retroactive liabilities—liabilities that could otherwise force the abandonment of properties or the bankruptcy of property owners. The administration of such funds allows for the

coordination and rationalization of a nation's risk reduction activities. With centralized control of the system, pollution mitigation measures at sites presenting the greatest social risks could, in principle, receive priority. The caveat is that an effective, centralized system of risk identification and ranking does not currently exist and is difficult and costly to implement.

Firms that expect large retroactive liabilities to ultimately force the closure of their enterprises pose a particularly serious pollution threat. If the enforcement of liability is delayed due to an overburdened legal system or the slow pace of regulators in indentifying pollution sources, such firms have no incentive to reduce pollution in the period before enforcement occurs. Faced with the likely prospect of closure due to existing property contamination, such firms will find it profitable to pollute at will until the government forces them to cease their operations. A benefit of publicly provided cleanup funds, then, is that they increase the expected value of the firms, reduce the likelihood that firms will close as a result of retroactive liability costs, and thus lead firms to make investments in pollution control based on the now realistic ability to continue profitable operation well into the future. Since legal and regulatory enforcement of liability claims is likely to take some time in Central and Eastern Europe, this benefit of publicly provided cleanup funds is particularly important.

There are potentially significant problems associated with the use of pooled funds, however. Because the current owners of properties where cleanups are to be conducted will be reimbursed for the costs of cleanup, one problem is that price competition in the market for risk remediation services may be lessened unless the government polices a bidding process for such services. The market for environmental cleanup services, while sure to become increasingly competitive, is currently not competitive. Another problem is

that property owners have an incentive to engage in costly cleanup activities that might have little social benefit because the owners are, in effect, insured by the government. Limited fund levels combined with inflated remediation costs could swiftly deplete a pooled fund's reserves.

A more fundamental problem associated with pooled funds derives from the inability to adequately separate risks existing before a fund is set up from those created during the fund's lifetime. If pooled fund programs cannot effectively distinguish between retroactive and prospective sources of pollution, amnesty for retroactive liability would carry a significant danger—namely, that newly created hazards will be claimed as hazards created in the past, thus allowing property owners to escape liability for pollution they generated. Realistically, a complete assessment of retroactive liabilities in Central and Eastern Europe will take years. Thus, while pooled funds may have desirable

*Publicly provided cleanup funds increase the expected value of firms, reduce the likelihood that firms will close as a result of retroactive liability costs, and thus lead firms to make investments in pollution control based on the realistic ability to continue profitable operation.*

short-term benefits, it is unequivocally undesirable for them to become a permanent fixture in a government's environmental policy portfolio. If firms believe that all or even a fraction of their potential future liabilities will be borne by a subsidized government fund, the private incentive to invest in pollution

reduction would be reduced. Thus an important political question is how a pooled liability fund program can be effectively operated on a short-term basis and then phased out to create liability assignments that effectively internalize environmental costs.

## Escrow funds

Several governments in Central and Eastern Europe allow fractions of up to 100 percent of the purchase price of a property to be set aside in escrow and used for the cleanup of pollution on the property. In practice, escrow funds guard against the incentive problems created by a pooled, no-fault liability fund by placing clear limits on the amount of public funding that will be provided for cleanups. In addition, because they typically expire after a period of months, escrow funds limit the ability of new property owners to escape the costs of pollution that they generate in the future.

Like pooled funds, escrow funds provide some insurance against existing pollution costs for property purchasers. Compared with the alternative of strict and retroactive liability, such insurance discourages a government from setting a costly standard for cleanups once it sells a property. The reason is that costly cleanups deplete the escrow funds—which would revert to government coffers if not drawn down.

However, new property owners may have an incentive to deplete escrow funds as much as possible, since for them the funds represent a source of costless pollution remediation financing. The result is that government funds that could be used to address pressing environmental problems might instead be used to address relatively unimportant environmental problems. Investors will clearly seek to purchase the least polluted properties. If funds are dedicated to the further cleanup of these relatively clean properties, government revenue that could

be used to reduce environmental risks at relatively polluted sites would be reduced. As compared with escrow funds, pooled funds provide the government greater authority to determine the allocation of cleanup funds.

## The creation of an effective liability system

Both pooled fund and escrow fund systems will create a beneficial form of insurance against pollution liabilities, and thus will stimulate foreign and domestic investment and potentially smooth the transition to a tough future liability system. However, public funding of pollution remediation should be viewed as only a short-term means of addressing existing soil and groundwater cleanup issues in Central and Eastern Europe. Any permanent government subsidy of soil and groundwater cleanups will only continue to distort private property owners' incentives to reduce pollution.

*The challenge for Central and Eastern Europe is to publicly fund remediation of existing pollution in a way that leads private property owners to believe they will be responsible for the social costs of polluting activities in the future.*

Pooled funds present the best opportunity for targeting public funds to the cleanup of pollution posing the greatest health and ecological threats. However, they also represent a form a subsidy that might be politically difficult to dismantle. The challenge for the governments of Central and Eastern Europe, then, is to provide public funding for pollution remediation, but

in a way that leads private property owners to believe that in the future they will be responsible for the social costs of polluting activities. While it may be tempting to give generous liability amnesties to foreign firms in order to encourage investment, doing so may lead foreign firms to export environmental risks to Central and Eastern Europe. Limitations on existing liabilities are desirable, but there is nothing to recommend investment incentives created by weakened liability rules aimed at reducing future pollution generation.

The strict enforcement of private property rights (and the assignment of liabilities) is not a particularly effective way—in the short term—to guarantee a rational social approach to pollution reduction. The reason is that private interests pursued through a liability system need not coincide with the social interest when resources are severely limited. The economies of Central and Eastern Europe are not currently robust enough to support large resource expenditures aimed at the resolution of legal disputes.

It remains the case that the costs of existing pollution must be distributed in some fashion. Moreover, a system of incentives for future risk reduction is desperately needed if current environmental conditions are to improve. Pooled liability funds are likely to be the most politically and economically effective mechanism for distributing costs and reducing risks. However, they should be subject to safeguards—specifically, a limit on the duration of coverage, and requirements for eligibility to claim reimbursement of cleanup costs (such as the installation of pollution reduction technologies). Pooled funds are a necessary compromise between strict and retroactive liability and unrealistic attempts to perfectly and quickly separate responsibility for existing and future pollution.

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# Easy Riding in the Provision of Local Parks and Recreation Services

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**Empirical studies suggest that the number and size of local jurisdictions within a metropolitan area affect the level and nature of spending on local public goods by local governments. Recently, researchers at Resources for the Future conducted a study of local government structure and spending for local public goods in which they distinguished between nonexcludable goods—for which access cannot be limited—and excludable goods—for which access can be limited. The study yields evidence in support of the so-called easy riding hypothesis, which suggests that one community's provision of a nonexcludable good reduces neighboring communities' incentives to provide the same good. It also reveals that municipalities where the median income of households is less than that for their region of the country have a strong tendency not to finance the provision of a public good when the good is provided by a neighboring jurisdiction.**

One of the most important and contentious issues in the theory of public finance concerns the relationship between the structure of local government—that is, the number and size of local jurisdictions—and the level and nature of local government spending on public services. More than thirty years of theoretical work and a number of recent empirical studies suggest that the two are intimately and often surprisingly related. Although no consensus has been reached concerning its precise nature, the relationship between the two is of great policy interest because it is possible that desirable spending outcomes are affected or even prevented by the structure of local governments.

Perhaps the most well-known theory of local government finance is the seminal hypothesis formulated by the economist Charles M. Tiebout. According to the Tiebout hypothesis, individuals would choose to live in a community that provides their preferred level and type of public services if circumstances permit them to move from one community to another. The hypothesis requires that there be fragmented and numerous units of local government within a metropolitan area, each of which offers a different combination of services and taxes among which individuals can choose. When this is the case, Tiebout proposes, individuals would vote with their feet to choose the local community offering a mix of services best matching their preferences, thereby disciplining the spending patterns of local government. In short, the Tiebout hypothesis suggests that spending on public goods would be efficient if local governments were fragmented.

Several hypotheses state the converse of the Tiebout hypothesis—that is, spending outcomes would be inefficient if local governments were not fragmented. Perhaps paramount among these hypotheses is the so-called Leviathan hypothesis, which is articulated most forcefully by economists Geoffrey Brennan and James Buchanan. Brennan and Buchanan argue that, absent the interjurisdictional competition posited by the Tiebout hypothesis, government will act as a Leviathan (a vast bureaucra-cy) to maximize its share of the economy, and public spending will be inefficiently high. Indeed, a number of empirical studies have found that the level of public spending is greater when local government is less fragmented—that is, when a metropolitan area is represented by relatively few political jurisdictions—than when it is more fragmented. It is worth noting that Tiebout's reasoning could also be invoked to support the opposite of the Leviathan hypothesis—that is, local governments tend to spend too little for local services absent competition to boost spending for such services. Up to the present time, however, the Leviathan hypothesis is the hypothesis that is consistent with empirical studies.

## Nonexcludability in the provision of urban parks

The empirical studies referred to above have an important limitation in that they have largely ignored the degree to which different public goods and services are truly "local" goods and services. By definition, local public goods and services are provided to members of a group but are denied to nonmembers. Fire protection, police protection, and education are examples of services for which local authorities can easily deny access to nonresidents of a jurisdiction. To varying degrees, local authorities can ration access to local public goods and services such as libraries and sanitation and community development services and charge a fee to nonresidents of the jurisdiction for the use of such goods and services.

Local authorities have considerably more difficulty excluding nonresidents from other public goods such as environmental quality, roads, and local parks. While access to some recreation goods and services such as swimming pools and sports leagues may be limited to residents of the jurisdiction providing the services, access to most urban parks is not limited. Of course, services like

police protection, which we consider a largely excludable service, cannot be denied to nonresidents visiting a community. While nonresidents have to come on site to enjoy the benefits of either local police protection or local parks, they would be much less likely to visit a community in order to enjoy police protection than they would be to visit a community in order to enjoy local recreation facilities. This means that individuals would be more likely to consider parks in neighboring communities to be a substitute for parks in their own communities than they would be to consider police services in neighboring communities to be a substitute for police services in their own communities.

The inability to exclude nonresidents from urban parks and open spaces raises the possibility that the provision of local parks will be inefficiently low. From the perspective of a local community where a park is located, such provision might be efficient when its marginal costs to residents is equal to its marginal benefits, without consideration of benefits accruing to nonresidents. If some of the benefits of expenditures on a park by one community spill over to neighboring communities, each community may have an incentive to consume park services provided by its neighboring communities and to reduce its own park expenditures accordingly. The result of such strategic interaction among communities may be that too few parks are provided from the perspective of the metropolitan area taken as a whole.

This strategic interaction is related to one of the classic problems in public finance—the so-called free rider problem. This problem stems from the insufficient incentive that individual members of a group have to provide goods or services that can be enjoyed by all the members of the group. In the present context, the free rider problem is more accurately labeled the "easy riding" problem because communities would be expected to provide some level of nonexcludable goods, but not as high a level as if they took into consid-

eration the benefits that accrue to everyone within their metropolitan area.

Both the easy riding and Leviathan hypotheses suggest that increased fragmentation of a metropolitan area will lead to reduced provision of public goods. However, the hypotheses differ in their range of application and in their implications. While the Leviathan hypothesis suggests that a less fragmented metropolitan area might provide too much public spending on all public goods—from the viewpoint of economic efficiency—the easy riding hypothesis suggests that a more fragmented area might produce too little public spending on certain types of public goods.

## Preliminary analysis of spending by a metropolitan area as a whole

To investigate how local government structure affects spending on nonexcludable public goods, we performed a statistical analysis comparing expenditures for local parks and recreation services—which we characterize as nonexcludable goods—with expenditures on police, fire, and community development services—which we characterize as excludable goods. In the analysis we examined spending in 314 metropolitan statistical areas (MSAs) containing 3,508 municipalities with populations greater than 2,500 in 1982.

As a preliminary exercise, we compared per capita spending aggregated across all levels of local government within an MSA for nonexcludable goods and for our index of excludable goods in a system of two equations. In doing so, we departed from previous studies of the effects of local government structure on local public spending. These studies have measured spending for an undifferentiated bundle of goods, without accounting for the characteristics of different types of goods and for the attribute of excludability, in particular. They have found that this aggregate amount of spending depends negatively

on the number of independent political jurisdictions within an MSA—that is, the less fragmented a metropolitan area is, the more it spends on all public goods. This finding is consistent with the Leviathan hypothesis.

*The easy riding hypothesis suggests that, relative to spending on excludable goods, spending on nonexcludable goods such as local parks should decrease as the number of independent political jurisdictions within a metropolitan area increases.*

In order to find out whether the easy riding hypothesis is valid, our study differentiated between nonexcludable and excludable goods. The easy riding hypothesis suggests that, *relative to spending on excludable goods,* spending on nonexcludable goods such as local parks and recreation services should decrease as the number of independent political jurisdictions within an MSA increases. According to the hypothesis, the decreased spending on nonexcludable goods is due to the increased opportunity or tendency for easy riding. Hence, if both the easy riding and Leviathan hypotheses are valid, spending levels would be relatively low for all goods when there is a relatively high number of jurisdictions within a metropolitan area (as the Leviathan hypothesis suggests), and this correlation would hold even more strongly with respect to the provision of parks and recreation services as a consequence of the opportunity for easy riding. Our analysis indicates that the overall public spending of an MSA does conform to the predictions of the Leviathan and easy riding hypotheses, and the results of our analysis are statistically significant.

Although it has not been tested previously, an additional implication of the Leviathan hypothesis is that spending for all goods should increase as the geographic size of governmental units within a metropolitan area increases. The reason is that, other factors being equal, individuals residing in a large jurisdiction would have more difficulty relocating to another jurisdiction because, presumably, they would have to travel further, on average, to work and to the areas where their existing social activities are located. The geographic size of a jurisdiction would also seem to be important to the easy riding hypothesis because it serves as a proxy for the price of services provided in other jurisdictions within an MSA. Individuals residing in a large jurisdiction have to travel further to take advantage of nonexcludable goods provided by other jurisdictions than individuals residing in a small jurisdiction. The easy riding hypothesis suggests that, as the geographic size of a metropolitan area increases, spending on nonexcludable goods should increase even more than spending on excludable goods. The results of our analysis conform to this prediction, but they are not of sufficient statistical significance to confirm the accuracy of the prediction with confidence. To do this, we had to consider the spending patterns of individual municipalities.

## Analysis of spending by individual municipalities

Analysis of aggregated data on the overall public spending of an MSA provides little insight into the determinants of the potential strategic interaction among communities with respect to the provision of public goods. Therefore, we used spending patterns by individual municipalities as the basis for most of our research. Specifically, we estimated per capita spending on nonexcludable and excludable goods by individual municipalities with respect to several independent variables, one of which is

per capita spending on the same goods by other municipalities within an MSA.

According to the Leviathan hypothesis, an increased level of spending by one jurisdiction signals reduced competition among all the jurisdictions within an MSA. This implies that spending on all types of goods by a given municipality increases as such spending by other municipalities within an MSA increases, and vice versa. In contrast, the easy riding hypothesis predicts that spending for nonexcludable goods by a given municipality decreases as such spending by other municipalities within an MSA increases, and vice versa. Hence, in our estimation of per capita spending on public goods by individual municipalities, the Leviathan and easy riding hypotheses' predictions concerning the effect of other jurisictions' spending for nonexcludable goods on one jurisdiction's spending for such goods are diametrically opposed.

The effect predicted by the Leviathan hypothesis and that predicted by the easy riding hypothesis could both exist. To control for this, we separated the two effects by comparing patterns of spending on nonexcludable goods with patterns of spending on excludable goods within a system of two equations and compared estimated coefficients across the system. In our estimation, coefficient values represent the percentage change in the level of spending by each municipality for the good characterized in each equation when there is a percentage change in each independent variable of interest.

If the easy riding hypothesis is valid, then the coefficient for spending in the equation for nonexcludable goods would be less than the coefficient in the equation for excludable goods. Our analysis showed that spending by each municipality for nonexcludable goods does depend negatively on the spending of other jurisdictions within an MSA and that the coefficient in the equation for nonexcludable goods is less than the coefficient in the equation for excludable goods, as the easy riding hypothe-

sis predicts. A statistical test of the probability that the coefficients in the two equations are equivalent revealed that probability to be less than 15 percent, given our data. This result provides some evidence of the influence of easy riding on the provision of nonexcludable goods. It appears that the spending levels of neighboring jurisdictions affect spending on nonexcludable goods and on excludable goods differently and in the manner suggested by the easy riding hypothesis.

Another variable of interest in our estimation of per capita spending on public goods by individual communities is the geographic size of a jurisdiction. As noted above, the Leviathan hypothesis predicts that spending for all types of

*It appears that the spending levels of neighboring jurisdictions affect spending on nonexcludable goods and on excludable goods differently and in the manner suggested by the easy riding hypothesis.*

goods will increase as the geographic size of a jurisdiction increases. The easy riding hypothesis would seem to predict an increase in spending for nonexcludable goods only. Hence, theory predicts that the coefficient in the equation for nonexcludable goods should be strictly greater than the coefficient in the equation for excludable goods. Our analysis did not find this to be the case.

## Factors that complicate analysis of spending on nonexcludable goods

Several important considerations complicate the estimation of our equations for spending on nonexcludable goods

and excludable goods and thus the interpretation of results reported thus far. One is that access to parks and recreation services provided by one jurisdiction can sometimes be denied to residents of neighboring jurisdictions. With some effort, access to recreational activities such as exercise classes and sports leagues can be controlled through enforcement of residency requirements; with considerably more effort, nonresidents could be denied access to local parks altogether. Another consideration is that current public spending on local parks may not be a good measure of the availability of parks. Better measures of this availability might be the acreage of parks in local jurisdictions or the cumulative past investment by local jurisdictions in recreation facilities; however, nation-wide data on both park acreage and past recreation investment are difficult to find. Given that local parks and recreation services are not entirely nonexcludable goods and that current public spending on local parks may not be a good measure of the availability of parks in neighboring jurisdictions, the easy riding effect might be stronger than our imperfect measures indicate.

While we were not able to take the above considerations into account in our analysis, we were able to take into account other factors that complicate analyses of how government structure affects local public spending. One of the most important of these factors is expenditures for local public goods by more than one level of government within an MSA. In many cases, county governments or special districts, which may serve part or all of one or several counties within a metropolitan area, provide a vehicle for spending on certain types of local public goods. If easy riding is a widespread phenomenon, one would expect local governments to attempt to mitigate it by coordinating their spending activities through these governments or districts.

While we can separate the amount of spending by a county government from the amount of spending by individual municipalities within a county, we cannot discern whether county governments are providing services only to unincorporated areas, as opposed to the county as a whole—including incorporated municipalities. It is even more difficult to tell precisely which populations or geographic areas within an MSA are served by special districts. To account for this difficulty, we examined a subset of our data on spending by only those metropolitan areas not served by special recreation districts, and separated spending by county governments from spending by municipalities within those areas. Although one might suspect that the previous results of our analysis of per capita spending on nonexcludable and excludable goods by individual municipalities were biased by the spending role played by special districts, we found them to be robust.

## Median income and spending for nonexcludable goods

We found that the most important variable affecting per capita spending on parks and recreation services is the median income of households within a municipality. In an early pretest estimation of such spending using a random selection of 120 municipalities, we discovered that, in low-income communities, per capita spending on parks and recreation increases as income increases and that, in high-income communities, per capita spending on parks and recreation decreases as income increases.

We subsequently divided the municipalities according to median income for each part of the county and estimated equations for spending on nonexcludable goods and for spending on excludable goods for the poorest 50 percent of municipalities and for the richest 50

**Disaggregate Variables for Poor Municipalities in Metropolitan Statistical Areas with No Special Recreation Districts**

| Object of spending by a given municipality | Spending by other counties and municipalities for same services: coefficient value (P-value)[1] | Geographic size of a jurisdiction: coefficient value(P-value)[1] |
|---|---|---|
| Parks and recreation services (nonexcludable goods) | -0.097 (0.554) | 0.375* (0.001) |
| Police, fire, and community development services (excludable goods) | 0.170* (0.050) | 0.116* (0.030) |
| Estimated probabilities that these coefficients are equal[2] | (0.143) | (0.035)* |

[1]The first number for each variable is the coefficient value, which represents the percentage change in the level of spending by each municipality for the goods in the left-hand column when there is a percentage change in each independent variable of interest. Each number in parenthesis is the P-value for a statistical test (T-test) of the hypothesis that the coefficient is actually equal to zero. The P-value reports the probability of obtaining these results if the true value of the coefficient is zero.

[2]These probabilities report the P-value for a statistical test (F-test) of the hypothesis that the coefficient values across the two equations are actually the same. The P-value reports the probability of obtaining these results if the true coefficient values are identical.

*Signifies the usual measure of statistical significance where coefficients have P-values less than or equal to .05.

percent of municipalities. We found the difference between low-income municipalities and high-income municipalities to be striking with respect to easy riding. The easy riding effect appeared to be strong among the poorest 50 percent of municipalities, but it disappeared among the richest 50 percent of municipalities.

A statistical analysis of spending for public goods by a subset of the poorest 50 percent of municipalities yielded some particularly interesting results. This subset was composed of 491 municipalities where the median income of households is less than that in their region of the *country*. Each of the municipalities is located in a metropolitan area that does not have a special recreation district. Again, we related the percentage change in the level of spending by each municipality for parks and recreation services and for an index of excludable goods to the percentage change in each of our independent variables of interest: spending by other jurisdictions within an MSA and the geographic size of a jurisdiction (see table, p. 10). We found that spending on parks and recreation services by the 491 municipalities decreases when spending by other jurisdictions increases, while spending on the index of excludable goods by the municipalities increases when spending by other jurisidictions increases. We also found that spending on both nonexcludable and excludable goods increases as the geographic size of the jurisdiction increases, but that spending on parks and recreation services is more sensitive to the geographic size of a jurisdiction than is spending on excludable goods. The relative ordering of the coefficient values for the spending and geographic size variables between the equation for nonexcludable goods and the equation for excludable goods is consistent with the easy riding hypothesis, and the coefficients and statistical tests (see table) indicate that easy riding strongly influences the provision of nonexcludable goods in the 491 municipalities.

There are several possible explanations for the importance of income to spending on nonexcludable goods. One is that families in high-income communities tend to take advantage of private recreation opportunities rather than public recreation opportunities. Studies have found that private clubs or large residential lots tend to substitute for public parks in high-income communities. However, it is also possible that individuals use recreation services provided by jurisdictions of which they are not residents only when those services are of a higher quality than the recreation services provided by their own communities. If this is the case, one would expect to find the greatest easy riding among the poorest communities. On a broad level, the provision of nonexcludable local public goods by high-income communities may serve to accomplish a type of income distribution, providing services that cannot be afforded or are in any case provided at a lower level by low-income communities.

## Policy implications

An important limitation of empirical studies of this type is that typically they cannot confirm or deny theory. Rather, they can at best demonstrate whether the data appear consistent or inconsistent with theory. Previous empirical studies of local government spending have been careful not to make claims about whether patterns exhibited in local public spending reflect optimal or suboptimal levels of spending, and we emphasize the same.

We find evidence consistent with the easy riding hypothesis. All other factors being equal, the easy riding effect should lead to under-provision of nonexcludable local public goods, from the viewpoint of economic efficiency. However, if the effects predicted by the Leviathan hypothesis or other effects are also influencing local public spending, the net effect is difficult to evaluate.

From our perspective, an important implication of our research is the possibility that easy riding affects expenditures for nonexcludable local public goods and services that are less easy to measure than expenditures for parks and recreation services. Quality of the environment in metropolitan areas is the public good that most directly affects people during the vast majority of their daily lives. The factors that determine environmental quality in any one jurisdiction have effects on the environment in neighboring jurisdictions. We are currently extending our research to assess the influence—if any—of easy riding on the design of various local government policies that affect the quality of the environment.

Our research also highlights the distinction between economic efficiency and optimality. We have uncovered evidence that differences in median income among communities has an important bearing on the tendency to easy ride. From the perspective of individuals residing in a relatively wealthy local political jurisdiction, easy riding may be an unwelcome effect. Nonresident users of public facilities contribute to the congestion of public facilities, and they might also spur the substitution of private goods for public goods, as when private recreation clubs and residential lots take the place of local public parks. From a broader perspective, however, the implied income redistribution that might be accomplished through easy riding may be a positive development. The definition of economic efficiency hinges on the definition of the political jurisdiction for allocating resources, and the optimal level of the provision of local public goods ultimately lies in the political domain.

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# In Pursuit of a Sustainable Space Environment: Economic Issues in Regulating Space Debris

Molly K. Macauley

**Debris resulting from human enterprises in space could seriously hinder space activities in many orbital locations within a few decades. It may be useful to conceptualize management of such debris in terms of sustainable development on Earth. Like a sustainable Earth environment, a sustainable space environment would meet the needs of the present generation without compromising the ability of future generations to meet their own needs. Accordingly, some debris may be endurable as long as its effect on future generations can be offset. Given that entities engaged in space activities may not be motivated to cover social losses resulting from the proliferation of debris and that such losses may be much greater than private losses resulting from the collision of spacecraft with debris, regulation of debris-generating activities may be desirable. In light of uncertainty about the proliferation characteristics of debris and the difficulty of specifying the benefits and costs of space activities, regulation must be considered carefully. However, regulation that incorporates economic incentives for debris control may be promising.**

Debris resulting from human activities in space is a growing concern. Ranging from used rockets and derelict satellites to particulates from propellant fuels, such debris can collide with and destroy operating spacecraft. Even small pieces of debris can cause substantial damage.

For example, an aspirin-sized piece of aluminum that orbits at a typical velocity of about 10 kilometers per second has the same destructive energy as a 400-pound safe moving at 60 miles per hour. While most experts agree that the current level of debris is manageable, they caution that, at the rate at which it is accumulating, debris could render many orbital locations unusable within twenty years.

The amount of debris in space is estimated to be doubling every decade. This rate of accumulation is in part due to the self-propagating behavior of debris. Even without encountering any artificial objects, debris can proliferate in a chain reaction of collisions with other debris, including natural debris such as micrometeoroids. In response to the growing threat posed by debris, decision makers have begun to consider strategies to slow the increase of debris resulting from human activities and develop techniques to protect spacecraft from debris. While the magnitude of the cost of such strategies has not been estimated with certainty, it is expected to be large.

Although the space debris problem will loom larger in the future than it does in the present, it must be addressed today if near-Earth space is to be preserved for the use of future generations. Viewed in this context, the issue of space debris is comparable to the issue of sustainable development on Earth. Sustainable development could shed light on how to conceptualize the space debris problem. Moreover, international support of economically oriented strategies for achieving sustainable development—such as debt-for-nature exchanges and transactions to commercialize biodiversity in tropical areas of the world—suggests that similar strategies for mitigating space debris may be politically acceptable. International support for economically oriented strategies is crucial because debris in space is an international problem.

## A sustainable space environment

As a concept for preserving Earth's resources, sustainable development is generally taken to mean no net loss over time in the global stock of human and natural capital associated with environmental quality, atmospheric integrity, natural resource adequacy, biodiversity, and other desiderata. Such development would meet the needs of the present generation without compromising the ability of future generations to meet their own needs.

With regard to space, an analogous concept might be a "sustainable space environment." According to one interpretation of this concept, the environmental impacts of present-day space activities need be moderated only at the point at which they unduly compromise future generations. Just as sustainable development does not require the cessation of all polluting activities, a sustainable space environment would not necessarily require the absence of debris in space. Some amount of debris may be endurable. The amount may be large or small, depending on whether technologies exist to offset the effects of space debris on future generations' ability to meet their needs.

Ascertaining the point at which present-day space activities unduly compromise future generations is challenging because it requires us to presume to know the preferences of future generations and to make judgments involving the moral, legal, and economic values of these preferences. Individuals who con-

tend that it is immoral, or unfair, or both to presume to know the preferences of future generations or to choose a discount rate with which to link present-day and future space activities might suggest that no space debris generated by people is endurable unless it can be fully cleaned up. This means that humans would be permitted to generate debris only if the effects of that debris on future generations are fully reversible.

As virtually every space activity generates some debris, eliminating debris would be tantamount to ceasing space activity. This is why decision makers have generally recognized the desirability of minimizing or reducing debris rather than eliminating it. Assuming, then, that a sustainable space environment is one in which there is some socially optimal amount of debris, several questions arise: to what extent should debris in space be reduced? and, how much should be spent to reduce debris? I will argue that the costs of reduction need to be balanced against the benefits of reduction. Weighing these costs and benefits will indicate the desirability of adapting to debris and pursuing some combination of debris reduction and debris adaptation actions.

## An endurable amount of debris

Debris in space is a by-product of activities that provide many benefits. Satellite communications, for example, enhance the quality of life. Remote sensing of Earth from space contributes to national defense and provides information about weather conditions and the quality of the environment. Interplanetary exploration and experiments conducted in space augment our stock of knowledge. If we are to continue to reap these and other benefits from space activities, we must be willing to endure some debris generated by these activities. If we are, we must determine what amount of debris is endurable and how we can control debris so that it does not exceed this amount.

The problem of debris in space is somewhat different from the problem of pollution on Earth. When pollution is unregulated, polluters will pollute excessively because they can generally enjoy the benefits without bearing the costs of polluting activities. These costs

*Given uncertainty about who or what will be affected by debris, spacecraft owners may have an incentive to contribute proportionately more to the total amount of debris in space than they may expect to benefit from their own efforts at debris reduction.*

are borne for the most part by third parties—that is, parties other than the polluters. However, the costs of debris generation can be borne by generators of the debris (spacecraft owners, for example) as well as by third parties. One aspect of this mutual harm is that, by taking actions to protect their spacecraft from debris, spacecraft owners can reduce harm to both themselves and third parties. For example, if they placed shields on their spacecraft, spacecraft owners would reduce the likelihood that spacecraft would be harmed by debris and therefore the likelihood that spacecraft themselves would be a source of debris.

This reduction in mutual harm—or increase in mutual benefit—is not guaranteed, however. Because the vastness of space and the way in which debris propagates and migrates through various orbital planes complicate predictions about who or what will be affected by debris, spacecraft owners are likely to shield their spacecraft to the extent that it benefits themselves rather than to the extent that it benefits third parties as well. Indeed, they may have an incen-

tive to pollute excessively—that is, to contribute proportionately more to the total amount of debris in space than they may expect to benefit from their own efforts at debris reduction.

Given the costs associated with debris prevention, is there any situation in which the socially optimal level of debris resulting from human activities might be close to zero? The answer is yes, but only if the benefits of debris-generating activities never exceed the costs of debris reduction. In orbits that have no atmospheric drag to remove debris and in orbits that are highly traversed by spacecraft, the optimal level of debris resulting from human activities may be close to zero.

At the other extreme, is there any situation in which the socially optimal level of such debris is unconstrained? Again the answer is yes, but only if the benefits of space activities increase at a faster rate than the costs of debris reduction. In the early days of spacefaring, benefits did increase faster than costs. This is generally no longer the case.

## Benefits and costs of a sustainable space environment

In addition to controlling the amount of debris generated in space, there may be other desiderata associated with preserving the environment of space. One objective might be to improve the capability to accommodate increases in the amount of space debris. This might be achieved by developing technological innovations—such as shields for spacecraft and debris "vacuum cleaners"—to adapt to debris, as well as by ensuring that increases in the amount of debris occur gradually rather than abruptly, such that future generations have time to develop their own techniques for adaptation.

Another objective of a sustainable space environment might be to improve our ability to specify the location, rate of proliferation, and other parameters of debris. Present-day technology allows

us to detect and track only those pieces of debris that exceed 10 centimeters in diameter. The probability, size, and economic consequences of collisions of artificial objects with debris too small to detect are difficult to model and quantify, as is the rate at which debris proliferates as a result of collisions that create additional debris. Advances in modeling and quantifying these parameters of debris could significantly increase the ability of present and future generations to adapt to debris.

A risk-based setting of priorities for remediating the hazards of debris resulting from human activities is another possible goal of a sustainable space environment. Presumably, the highest priority would be given to remediating the most egregious hazards, unless remediating less egregious hazards would contribute as much to overall remediation at lower cost. Priorities might range from the removal of the upper stages of rockets to the venting of excess propellant from these stages, which would reduce the potential for and the severity of chemical explosions.

Another objective of a sustainable space environment might be some notion of fairness in terms of who wins and who loses, both now and in the future, as a result of space activities and efforts to mitigate debris hazards. Issues of fairness could pit spacefaring nations against nonspacefaring nations, or developed countries against developing countries. They could also pit commercial entities against government entities if the latter do not assess the relative burdens of the cost of collisions of spacecraft with debris and the cost of debris control on the former. If commercial launch vehicles or payloads are harmed by debris, commercial space companies would lose revenue and face increased insurance rates. However, efforts to control debris raise the cost of space activities. What is needed are policies that adroitly balance the benefits and costs of debris control.

The cost of mitigating debris includes several direct costs: the cost of mitigation activities; the cost of monitoring these activities; and, if the activities are undertaken in response to government regulation, the costs of enforcing the activities. These costs are privately borne by aerospace firms and by the budgets of government's defense and space agencies. The cost of mitigating debris also includes indirect costs arising from the effects that the direct costs of controlling debris have on the pace and direction of long-run technological innovation and from the effects of the self-propagating nature of debris on future space activities. These costs are more generally borne by society.

Individual governments or companies are likely to ignore socially borne costs. If these costs are larger than privately borne costs, it may be desirable for governments, industry consortia, or other centralized entities to regulate debris generation. However, the costs of regulation must be smaller than the social costs of debris control for regulation to make economic sense.

## Potential economic impact of debris

Before focusing on strategies for mitigating debris, the potential economic impact of debris on space activities warrants some consideration. The monetary loss associated with a space activity not completed as a result of the collision of a spacecraft with debris can be experienced not only by the agent who is carrying out the activity—a corporation, a particular scientific community, or an agency such as the National Aeronautics and Space Administration—but by society as well. Thus expected monetary loss should be distinguished as "private expected loss" and "social expected loss."

One way to measure private expected loss is to multiply the cost of a space activity by the probability that a spacecraft in the orbit in which the activity takes place will collide with debris during its average operating lifetime. The assumptions implicit in this calculation are that the collision completely curtails
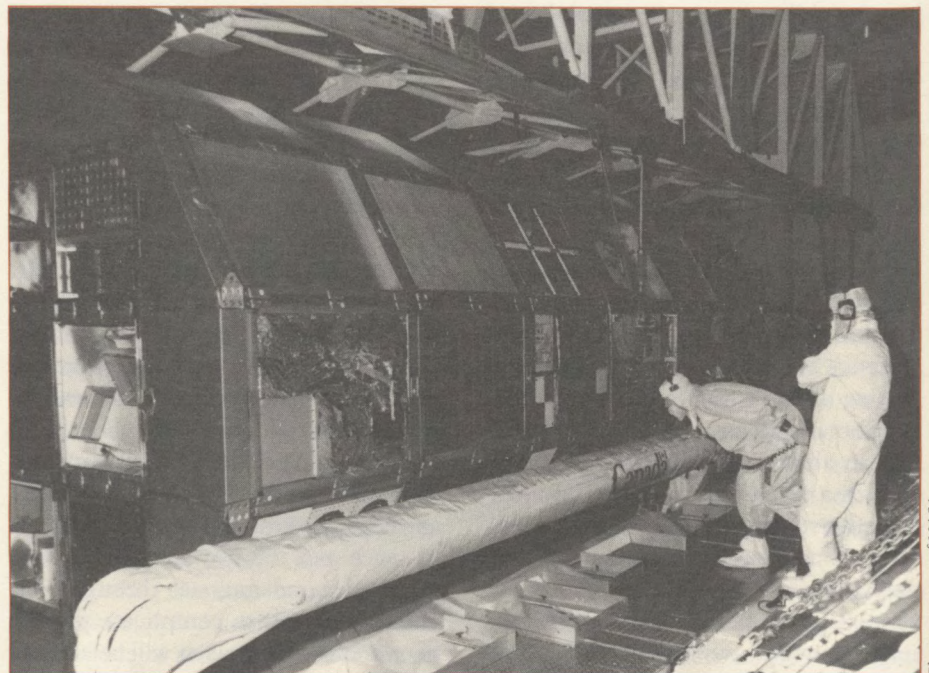


The Long Duration Exposure Facility, which carried 57 experiments, was designed to test the performance of spacecraft materials, components, and systems that have been exposed to the space environment for a long time. Scientists began evaluating the condition of the satellite, which orbited Earth for nearly six years, after it was retrieved by the space shuttle Columbia on January 12, 1990.

Photo courtesy of NASA

the activity and that the cost to replace the activity can be approximated by adjusting the original cost of the activity for inflation.

One way to measure social expected loss is to estimate the costs that would be imposed on society by the collision of spacecraft with debris. These costs might reflect the contribution of a collision to debris in different orbits or in various longitudinal locations—some of which are more valuable and populated than others—along the geostationary orbit. (The geostationary orbit is the orbit in which most communications satellites that transmit live sports events, news, and other information are located.) These costs might also reflect the contribution of the debris to delays in a space program—for example, delays due to special investigations of or public concerns about the loss of a space shuttle as a result of the shuttle's collision with debris.

The relative (rather than absolute) magnitudes of private losses and social losses suggest that losses for private agents may be significantly smaller than losses for society at large. Consequently, private agents—who confront only private expected losses—may not find it worthwhile to take actions to mitigate the impact of debris on space activities. Consider the following scenario. A commercial communications satellite is nearing the end of its operating life, at which point it will be debris. A few months' to one year's worth of the satellite's fuel supply is needed to boost the satellite out of its geostationary orbit. If a year's worth of fuel is needed, the satellite would cease operation one year earlier than planned; consequently, the satellite operator would forgo several million dollars in revenue. To induce the satellite operator to boost the satellite out of its orbit, another spacecraft operator would have to compensate the satellite operator in this amount. However, the spacecraft operator is unlikely to so, as he or she faces a private expected loss due to damage caused by debris of only $500,000.

This private loss is small because the estimated probability that the satellite will be damaged by debris is low. The probability that a space shuttle will be damaged by debris is also likely quite low, given the brief amount of time a shuttle is in orbit. While the estimated cost of a shuttle flight—which is based in part on imputed value-of-life estimates for the shuttle crew—is on the order of $1 billion dollars, the private expected loss due to a shuttle's collision with debris can be much smaller.

The social expected loss values for space activities may be much larger than private expected loss values, as the risks posed by debris are increasing. Debris experts estimate that the probability of a geostationary satellite colliding with debris will increase from .001 to .4 by the year 2000. Based on this estimate, private expected losses will increase from $0.5 to $200 million in 1992 dollars. The difference in these losses, about $200 million, reflects the costs imposed on operators of satellites in the year 2000 by today's satellite operators, given current launch rates, the operating parameters of today's satellites, and the potential of today's satellites to contribute to debris in space. Thus some fraction of the $200 million could be ascribed to each of today's satellites to represent its social loss.

Parties engaged in space activities may be motivated to take actions to cover their private expected loss values—to use insurance to cover losses due to debris or to place shields around spacecraft to protect their payloads, for example. However, they may not be motivated to cover social expected loss values by taking actions to prevent debris generation, such as using lanyards to secure external components of spacecraft or boosting spent spacecraft out of the geostationary orbit. If so and if the differences between private and social expected losses are large, regulation may be desirable to compensate society for losses resulting from the proliferation of debris resulting from human activities.

## Debris mitigation strategies and techniques

The most desirable types of strategies for mitigating debris are those that would minimize the sum of debris control costs and damage costs, thereby allowing the widest range of opportunities to achieve given debris mitigation goals. Limiting the ways that entities directly involved in space activities can contribute to a given overall reduction in the level of debris would probably increase the costs of complying with regulations to control debris. Therefore, flexible strategies, which would allow such entities to implement least-cost debris mitigation techniques, are desirable. This means that debris mitigation techniques should probably not be limited to reducing debris at the source—for example, by designing and operating spacecraft in such a way that their potential to explode or break up is reduced, venting excess propellant, using lanyards to secure external spacecraft components, or boosting geostationary satellites into so-called disposal orbits. Rather, they should also include recycling, changes in the production or operation of spacecraft, and "end-of-pipe" controls. Recycling would involve the capture and reuse of spacecraft or spacecraft components. Production and operation changes would involve the attachment of shields to and the incorporation of redundant components in spacecraft, and the modification of a spacecraft's orbital parameters. End-of-pipe controls would involve the removal of manmade debris from space and improved and increased monitoring, modeling, and measurement of debris, which would allow spacecraft to avoid debris.

Strategies for reducing debris can be evaluated on the basis of their expected costs and their expected benefits, which are defined as the objectives of a sustainable space environment. A number of strategies may garner these benefits. They include actions that parties may voluntarily and unilaterally take to reduce debris and actions they may take

in response to moral suasion such as exhortations from governments, industry associations, or others to reduce debris. Both types of action would foster a sustainable space environment but might not be as likely as other actions to garner all four of the above-noted benefits.

Command-and-control regulation, in which government would specify the technologies and methods to be used in mitigating debris, would attain these benefits. However, if the general experience with command-and-control regulation of polluting activities on Earth is any indication, it would do so at a fairly high cost, given that it does not allow regulatees to take what for them would be the least-cost approach to complying with regulation.

*Because the most desirable types of debris mitigation strategies minimize the sum of debris control costs and debris damage costs, techniques for mitigating debris should not be limited to reducing debris but include recycling, changes in the production or operation of spacecraft, and "end-of-pipe" controls.*

Other potential regulatory alternatives include economic penalties for debris generation, including compensation that might not be strictly financial but might consist of transfers of in-kind resources (such as technology transfer) to non-spacefaring nations or to other parties harmed by debris, and taxes or fees levied on particular stages of space activities. The latter could include deposit-refund schemes whereby deposits made on the launch of spacecraft, for example, are refunded when components of the spacecraft are boosted to disposal orbits,

excess propellant is vented, and so on. Yet other regulatory alternatives might include tradable permit schemes, in which commercial space firms and other entities would be allowed to trade permits to generate some specified amount of debris; reliance on insurance markets and liability law to assign financial responsibility for debris generation and thereby reduce it; and bonds purchased for space activities. Such bonds, which would be redeemable upon proof of compliance with overall debris reduction goals, would be similar to insurance but would be specifically linked to debris mitigation actions. Like deposit-refund schemes and insurance, performance bonds would likely be less difficult to monitor and enforce than other debris control alternatives because they would encourage self-policing.

Regulatees' perceptions of the fairness of the above debris control strategies would be based on compliance costs and on other factors that operate to shift distributions of wealth or that affect a party's technological prowess or prestige. Actions taken voluntarily, actions taken in response to moral suasion, command-and-control regulation, financial penalties, insurance, and performance bonds might be perceived as fair by regulatees for whom compliance costs and distributional effects are small, but perceived as unfair by those who face high costs and large redistributions of wealth. Financial penalties for debris generation that explicitly compensate regulatees who face higher compliance costs than other regulatees, or deposit-refund and tradeable permit schemes that seek to minimize the cost burden, might be seen as fair. Taxes might be considered unfair unless the tax revenues are redistributed to regulatees or fees are graduated according to some generally agreed-on bases.

None of the above debris control strategies appears to outperform the others on all bases. However, the economically oriented strategies, especially those that encourage self-enforcement, may be promising.

## Need for international cooperation

To be effective, debris mitigation actions will probably require the consensus of those currently using space, those who will be using space in the future, and those who may never use space directly but who benefit indirectly from space activity. If the record of global environmental cooperation on Earth is any blueprint, however, reaching consensus on space debris policy may require an explicit resolution of the potential clash between environmental protection of space and the development of spacefaring capability by nations not presently active in space. With respect to sustainable development on Earth, accommodating global environmental protection and individual countries' economic development has been difficult due to the lack of or argument over the specification and sharing of property rights.

Similarly, the muddled specification of rights in space is bound to complicate space debris policy. Assigning property rights may be viewed as contrary to international law. However, assigning countries responsibility for minimizing debris in specific orbital locations—such as the geostationary orbit—could be tried, particularly as countries geographically positioned to best use various geostationary orbits already have incentives to boost spent satellites to disposal orbits in order to make room for their own next-generation spacecraft. Nations or regions might also be assigned responsibility for tracking and monitoring debris generation and for enforcing compliance with debris control regulation in various orbits. As an inducement to take on this responsibility, they could be given assistance in developing their own tracking and monitoring technology.

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# Environmental Policy as Industrial Policy

Karen L. Palmer and R. David Simpson

Those who believe the United States should be a leader in development of environmental technology advocate industrial policies to improve the performance of U.S. industry. These policies include the subsidization of research and development in the area of environmental technologies and, paradoxically, the strengthening of domestic environmental regulations. Researchers at Resources for the Future recently examined three potential justifications for using such subsidization or tough environmental regulations as ways to enhance the international competitiveness of domestic firms. They find each to be based on unlikely assumptions and inconclusive anecdotal evidence. Subsidization of research on environmental technologies might be more effective in conferring an advantage on domestic firms vis-a-vis foreign rivals than the use of environmental regulation as an industrial policy tool, but both options may represent an unreasonable "something-for-nothing" view of environmental policy alternatives.

A number of political figures have recently argued that the United States needs to encourage the development of environmental technologies more actively. These individuals have noted with concern the fact that the United States invests a smaller proportion of research and development (R&D) funds in environmental technologies than do Japan, Germany, and some other major industrial countries. They have also cited a number of instances in which countries with strict environmental regulation have taken the lead in industries affected by the regulation. For those who believe the United States must become a leader in the development of environmental technologies if it is to enhance the international competitiveness of U.S. industry, the announcement by The Ministry for International Trade and Industry (MITI) in Japan of plans to launch a long-term program to develop so-called green technologies is perceived as a challenge.

This challenge is being answered in attempts to advance such technologies as an element of U.S. industrial policy. For example, Senator Barbara Mikulski (Maryland) has proposed the establishment of a National Environmental Technologies Agency; Vice President Gore has advocated a Strategic Environment Initiative; congressional committees have held hearings on other environmental initiatives in recent months; and the Clinton administration has argued for collaborative research on low-emission vehicles.

Calls for public assistance in the development of environmental technologies are occurring simultaneously with the growth in popularity of a new perspective in the debate on environmental regulation and competitiveness. Subscribers to this new perspective, which we label the revisionist view, make the paradoxical claim that strict environmental regulation may actually enhance industrial competitiveness.

This claim is contrary to conventional economic wisdom, which suggests that such regulation compromises industrial competitiveness. If the United States adopts environmental standards stricter than those of its foreign industrial rivals, U.S. firms would experience increasing costs, declining production, reduced employment, and decreased profits. Thus the United States may end up importing products it now makes domestically and "exporting" jobs, profits, and environmental degradation to countries with laxer environmental standards.

In contrast, the revisionist view suggests that, rather than placing the United States at a disadvantage relative to its industrial rivals in Europe and in Asia, the tightening of U.S. environmental standards will stimulate U.S. growth. According to one of the most noted proponents of the revisionist view, Dr. Michael Porter of the Harvard Business School, there is no real conflict between environmental protection and economic competitiveness. In "America's Green Strategy" (*Scientific American,* April 1991), Porter suggested that, rather than stifling productivity, environmental protection enhances competitiveness in the long run. Tough environmental standards will lead firms to make better products by less costly methods. U.S. firms will become world leaders in their industries, and they will be in a position to export or license their new-found technologies abroad.

Is there any validity to the arguments put forth by Porter and other proponents of the use of environmental policy to achieve industrial policy objectives? To find out, we recently analyzed the assumptions underlying and anecdotal evidence offered in support of three potential justifications for using environmental policies, such as the subsidization of R&D in the area of environmental technology and the promulgation of tough environmental regulations, as industrial policy tools. The first justification is that U.S. firms are inefficient and fail to recognize and pursue profitable opportunities to innovate in the area of environmental technology. The second is that firms find it difficult to prevent other firms from appropriating their innovations in envi-

ronmental technology. This difficulty limits firms' incentives to engage in research on environmental technologies. The third is that the international performance of U.S. firms can be improved through the strategic setting of domestic environmental policy goals.

## Inefficient production practices and short-sighted firms

It is sometimes suggested that firms are unable to recognize profitable innovation opportunities without a prod from the government. The failure of U.S. firms to develop new environmental technologies is seen as a failure on their part to anticipate future demand for these technologies, even in light of the expected tightening of environmental standards worldwide. Assuming that U.S. firms cannot identify profitable new technologies, is it likely that government regulators or legislators can consistently identify them? Probably not. If a lack of information prevents firms from identifying profitable investment opportunities, it seems likely that government agencies would face more, rather than fewer, difficulties in identifying them. Government intervention or regulation has sometimes led to firms' superior performance in the marketplace, but whether such intervention generally results in enhanced competitiveness is hotly disputed.

It is, of course, indisputable that private companies have blown many a sterling investment opportunity. One must ask, however, if such oversights are systematic failings or simply unfortunate occurrences. What might appear to have been foolish behavior on the part of a firm that did not make a certain investment may in fact have been perfectly rational given expectations about the prospects of gain. Analyzing a wide range of possible new ways to reduce costs or improve product quality is costly. Profit-maximizing firms will continue to search for ways to reduce costs or improve product quality until

the expected cost of doing so exceeds the expected gains.

It may well be that a new environmental regulation, or a subsidy for research on environmentally friendly technologies, leads to the discovery of unanticipated benefits. There are numerous instances in which this has been the case. However, it would be incorrect to infer that this implies a deficiency in private firms' research strategies. Before reaching this conclusion, one would want to know not only how many successes result from pursuing research, but also whether the successes are balanced by failures of environmental regulation or subsidization of research to bring about new production processes or products.

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*Policies designed to promote development of environmental technologies must discount the future benefits of that development according to society's willingness to forgo resources that could be used today for other purposes.*

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We must also note that being a leader in the development of green technologies is not necessarily an end in itself. A firm may be profitable once it becomes a leader, but acquiring the position is expensive. The costs of developing new technologies are often incurred well in advance of the benefits. Moreover, the benefits are often speculative and uncertain. Firms will discount expected future benefits when deciding whether or not a particular R&D project is worth pursuing. U.S. firms that sell technologies to foreign firms or that abandon a particular R&D project in environmental technology may be behaving rationally if the current costs of bringing these technologies

to market outweigh the present discounted value of expected future profits. Any policy designed to promote development of environmental technologies must discount future benefits according to society's willingness to part with resources that could be used for other purposes today.

Numerous anecdotes suggest that the United States may be losing its position of leadership in the development of certain environmental technologies. Citing examples of the yielding of technology leadership by U.S. firms to foreign firms, advocates of a strong U.S. environmental technologies policy propose that the United States needs a national policy to reestablish U.S. industry as an environmental leader. This proposal is not soundly motivated. It would be unwise and, in fact, impossible to lead in all technologies and in all phases of the development of technologies. At times a country may find it is wiser to cede some projects to other countries better able to develop them and instead concentrate on those projects in which it enjoys an advantage.

On occasion, it may be perfectly reasonable, logical, and efficient to pass up opportunities for developing environmental technologies. However, there may be situations in which the reticence of firms to develop technologies arises more from laziness than from deliberation. Firms and their managers may be unable or unwilling to minimize production costs.

Deviations from cost-minimizing behavior are more likely to occur if there is little competition in the market for a firm's product than if there is great competition. The firm's managers may then be able to trade efforts aimed at reducing product costs for a less strenuous work schedule for their employees and themselves without fear of losing market share to a competitor that offers a similar product at a lower price. This may lead the firm to overlook R&D opportunities that could result in long-run cost reductions. If it were the case that U.S. firms are so effectively insulat-

ed against more efficient foreign competitors as to ignore cost-reducing opportunities with impunity, then U.S. firms would not require an industrial policy aimed at improving the performance of U.S. firms in order to save them from foreign competition.

Even if the objective is to improve the performance of U.S. firms—without regard to their stance relative to foreign competitors—failure to minimize production costs would be sustainable only if there were also information barriers or other imperfections in capital markets that prevent efficient managers from identifying the existing inefficiency and taking over the firm. The potential for the takeover market to discipline production costs may be limited when organizations are large and production processes are complex, and thus the process of identifying existing inefficiencies in operations is complicated. Of course, if organizations are large and production processes complex, it may be difficult for outsiders—such as government officials—to determine if there

is, in fact, substantial inefficiency. Without concrete evidence of inefficiency, tightening environmental regulations in the hope of inducing increased efficiency would be unwise.

## Difficulty of preventing appropriation of research and development

Another justification for environmental policies designed to promote research and development of environmental technologies is that, without such policies, firms may have little incentive to innovate when the benefits of a firm's R&D efforts are enjoyed by other firms. In many cases newly developed products may be "reverse-engineered" in order to uncover and replicate the process used to manufacture them. Preventing others from copying an innovation can be extremely difficult when the costs of replicating the innovation are very low. Patenting an invention or a new production process is one

means of protecting an innovation from duplication, but the costs of obtaining a patent, the often narrowly defined limits of patent coverage, and the amount of information conveyed in a patent document all pose limits on the degree of protection a patent can provide.

A firm may accomplish too little research and development when the firm finds it difficult or impossible to prevent other firms from reaping the benefits of the innovations resulting from its R&D efforts. The government may need to subsidize R&D efforts in order to obtain the socially efficient level of investment in such efforts. This appropriation problem may provide some justification for a government-sponsored technologies initiative.

Whether any policy to promote the development of green technology can be effective in promoting U.S. industry is open to question, however. If firms engaging in research and development cannot fully appropriate the benefits of doing so, there may be little advantage conferred on U.S. companies by any such policy. A U.S. policy of promoting research and development would only promote domestic industry relative to foreign industry if the spillovers from research and development are dramatically reduced at the U.S. border. In this age of multinational firms and increasingly international markets, it seems very unlikely that this would be the case.



Since 1984, the Idaho National Engineering Center has been conducting tests of electric-powered cars for the U.S. Department of Energy's electric vehicle dynamometer and road-testing program. In one attempt to advance so-called green technologies, the Clinton administration has argued that government and private industry should collaborate on research on low-emission vehicles such as electric-powered cars.

Photo courtesy of the U.S. Department of Energy

## Environmental policy as strategic trade policy

In the preceding discussion we have implicitly assumed that international markets are perfectly competitive, and thus free trade is the optimal government policy. Given this assumption, steps taken by government to increase the profits of domestic firms always backfire. Even if policy interventions increase the profits of the firms affected by the interventions, the benefits would be more than offset by losses elsewhere in the economy. While business advo-
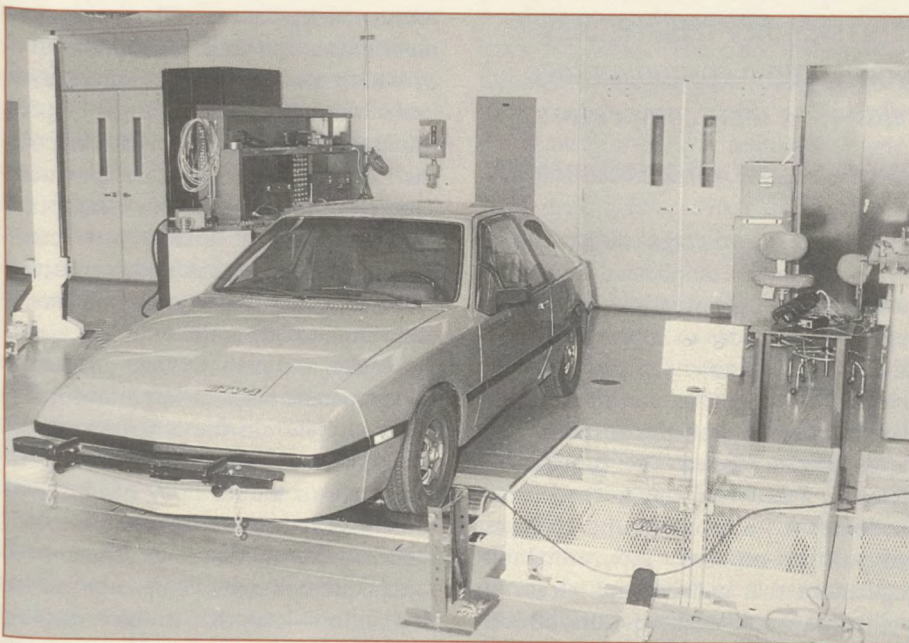
cates and policymakers often argue that government should establish what we would call today a strategic trade policy, economists have traditionally believed that nonintervention is the best policy.

This view has been challenged by the economists who have developed strategic trade theory. These economists challenge the questionable assumption that firms competing against foreign rivals do not attempt to affect their opponents' behavior. Given that the markets for many products are dominated by a few large firms competing head-to-head, this assumption is probably not realistic in many circumstances. Large firms can and do attempt to appease or intimidate each other by their choices of marketing, innovation, and export strategies.

Those who advocate strategic trade policy believe that profits may be shifted among international rivals. Aggressive marketing, innovation, and export strategies on the part of a nation's firms—or a nation's government—may create a competitive advantage relative to another nation's firms. Actions that lead to profit-shifting might be particularly important in understanding how environmental policy affects industrial performance. A U.S. firm might increase its profits at the expense of a Japanese or German rival, for example, by increasing its output. The foreign rival would respond by cutting its own output. Consequently, the U.S. firm would command a larger share of the market and earn higher profits.

One possible strategic trade policy scenario (described in greater detail below) that links environmental policy changes and increased profits for U.S. firms can be summarized like this: tougher environmental policies may induce innovation; innovation may reduce costs; reduced costs may result in increased output; increased domestic output may displace the output of foreign competitors; and the result may be increased domestic profits.

The developers of strategic trade theory recognize that domestic firms will increase their production if their costs decline. Costs might be made to fall through a number of means. A direct means is government subsidization of production, which decreases a firm's cost of production by the amount of the subsidy. An indirect means is government subsidization of investment in research and development, which leads to the creation of better products or to the ability to make a product at lower cost. Subsidization of either production or research and development expenditures might result in greater domestic production, sales, and profits.

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*It is suggested that tightened environmental regulation will secure competitive advantage by spurring innovation: if firms undertook innovations resulting in production processes that are cleaner and less expensive than the processes they replace, they would gain a cost advantage relative to their competitors.*

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Strategic trade theorists might make a somewhat more complicated argument in favor of toughening environmental regulation in order to secure industrial advantage. Investment in cost-reducing innovations is a substitute for expenditure on inputs into production. By developing an efficient steel furnace, for example, a steel company might be able to decrease its input of and thus its expenditure on coal. Environmental regulations that penalize the release of pollutants would make the use of coal more expensive. This would, in turn, spur innovation. More generally, if firms undertook innovations that resulted in production processes that are not only cleaner but also less expensive than

the production processes they replace, they would gain a cost advantage relative to their competitors.

After carefully considering this argument for a country to toughen its environmental regulation in order to secure a competitive advantage for its industrial firms, we have come to mixed conclusions. While the scenario outlined above is theoretically possible, it is unlikely for several reasons. First, the entire argument rests on the presumption that innovations resulting in "clean" production processes also result in decreased production costs. This presumption should be carefully tested before it is made the basis of national environmental policy. Evidence concerning the effects of innovations in environmental technology on production costs consists more of anecdotes than of careful statistical analysis, and is inconclusive. Second, a policy that induces innovations in the long run necessarily raises costs in the short run. If output is to increase, the cost savings from innovations must more than offset the short-run costs of tightened environmental regulations. Third, the argument hinges on subtle assumptions, one of which is that firms compete with each other by choosing levels of production and then taking whatever price the market will bear for their products. The results arising from this assumption would *not* arise if, instead, firms compete by setting prices and producing whatever quantity of output consumers are willing to buy at the set prices.

Finally, and perhaps most important, the argument begs an important question: why should the government, by enacting stringent environmental policies, have to induce domestic firms to undertake innovation that would be in their own interest anyway? The answer to this question hinges on another subtle distinction—one that involves timing and credibility. In the strategic trade scenario we have sketched, both domestic and foreign firms would want to invest in more innovation to reduce production costs if they believed that by

doing so their rivals would invest less in innovation. The reasoning here is that advantage lies not so much in having "good" technology, as in having "better" technology than one's rivals. To be induced to develop better technology than its foreign rivals, a domestic firm would have to be confronted with an environmental policy that compels it to increase investment in innovation. Absent this inducement, a domestic firm might be unable to convince its foreign rivals that it would in fact be investing in cost-reducing innovations. If the rivals are unconvinced, they would not scale back their sales plans; and if they do not scale back their sales plans, there would be no incentive for the domestic firm to invest in innovation.

The objective of conferring an advantage on domestic firms vis-a-vis foreign rivals could be accomplished with a less convoluted scheme, however. As noted above, government subsidization of production or of research and development expenditures might achieve this objective. Tough environmental regulation might not, given that it calls for a trade-off between lower long-run costs due to innovation and higher short-run costs due to strict environmental standards. It is not clear whether the lower long-run costs or the higher short-run costs would dominate.

Compared with more direct alternatives for enhancing the international competitiveness of domestic firms, environmental regulation as a strategic industrial policy has perhaps only one advantage—namely, that it would be difficult for its intended beneficiaries to manipulate. Industrial policies are only in the national interest if the gains—in this context, the increased wages and profits in industries receiving subsidies—more than balance the cost to taxpayers of providing the subsidies. Industry might solicit subsidies for production or for research on and development of innovations even under circumstances in which such subsidies would not be justified. In comparison, the circumstances under which it would seek tough environmental regulation might be more limited. If in seeking to increase its competitiveness abroad U.S. industry called for the government to enact tough environmental regulation, the argument for such regulation would merit at least a serious hearing. However, the fact that industry does not often make such a request should cast serious doubt on the validity of the claim that strict environmental regulation confers an advantage on the firms subject to the regulation.

## Something for nothing?

It is important to point out that the question being debated is not whether there should be policies for environmental protection, but rather what policies are most appropriate. Environmental regulations yield important benefits, such as improved air and water quality, that are valued by society. The issue we focus on is the trade-off between increased pollution reduction on one hand and increased industrial production and economic growth on the other hand. The conventional economic wisdom suggests that there are indeed trade-offs to be made. Strengthening environmental regulation compromises production, jobs, and growth; subsidizing investment in environmental technologies imposes costs on taxpayers.

Some would argue that this is not the case. They would suggest that subsidies will provide net benefits above and beyond the environmental improvements they afford by making the United States the global leader in environmental technologies. Some also suggest that, by tightening its environmental standards, a country improves both the quality of its environment and its long-run industrial performance and does so without any sacrifice. This something-for-nothing environmentalism has to be questioned. Its plausibility is widely debated. While the subsidization of environmental technologies is attractive to the intended recipients of subsidies, it elicits considerable skepticism among less interested parties.

The revisionist view that U.S. firms would actually benefit from tightened environmental regulation is even more dubious than the case for environmental technologies subsidies. Such regulation has not garnered the support of the industries that would supposedly benefit from it. Advocates of the revisionist view imply that a sizable segment of American industry is incapable of figuring out what is in its own best interest. If this is not the case, and we assume it is not, ignoring the sentiments of American industry and designing environmental policies to achieve industrial policy goals would be dangerous.

There is another disturbing aspect of the revisionist view. It concerns the view's implications for international cooperation. If a country realizes a competitive advantage by quickly adopting environmental standards stricter than those of its industrial rivals, does the opposite conclusion—that a country would benefit if its industrial rivals slowly adopted tough standards—follow? Discussion of the merits of international harmonization of environmental standards raise a complex set of issues. Suffice it to say that this implication is not likely to be attractive to many environmental advocates.

Good environmental policies will confer net benefits, but even a good policy will create winners and losers relative to the status quo. Even if—especially if—society benefits from strict environmental policies, more meaningful progress toward the realization of improved environmental quality would be made by concentrating on how to share fairly the burden of cleaning up pollution than by making dubious assertions that solutions will be painless.

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## RFF sponsors energy tax briefing

Estimates of the economic, environmental, and distributional effects of the Clinton administration's proposed energy tax (Btu tax), taxes based on the carbon content of fuels (carbon tax), and taxes on gasoline were presented at a briefing sponsored by Resources for the Future on June 10. Those making presentations at the briefing, including three RFF fellows, came to four major conclusions. First, in comparison with more traditional tax alternatives, an energy tax entails larger nonenvironmental costs to the economy but has the attraction of inducing larger reductions in emissions of major pollutants. Second, a Btu tax and a carbon tax that raise the same amount of revenues would have a similar effect on the environment, but the carbon tax would affect households more unevenly across regions than a Btu tax. Third, a gasoline tax of 7.6 cents per gallon would reduce gasoline use by 3.3 percent and raise $7.5 billion each year in revenues, but would fall heavily on rural areas and the poor. Fourth, in New York City, a 7.6 cents per gallon gas tax would be a cost-effective way of reducing emissions of volatile organic compounds, which are a precursor to ground-level ozone.

Lawrence Goulder, associate professor of economics at Stanford University, compared the effects of the proposed Btu tax with the effects of an increased personal income tax and a value-added tax (VAT) on gross national product (GNP) and on emissions of eight air pollutants. According to his analysis, the energy tax would result in a larger reduction of GNP than would the increased income tax or the VAT. Goulder explained that the energy tax is more costly than either of these other taxes because it has a narrower base; it applies to intermediate production

inputs rather than income; and it taxes capital goods. While Goulder found the energy tax would be more costly than the increased income tax or the VAT, he noted that—unlike these taxes—the energy tax would reduce emissions of sulfur dioxide, nitrogen oxide, carbon dioxide, and five other pollutants. Since he did not attempt to value these emissions reductions, he concluded that it is not clear whether the reductions would be large enough to compensate for the higher cost of the energy tax—compared with the cost of the increased income tax or the VAT—in terms of effects on GNP.

Raymond J. Kopp, senior fellow and director of the Quality of the Environment Division at RFF, discussed research that he conducted with Hadi Dowlatabadi (coordinator of the Global Climate Change Integrated Assessment Program at Carnegie Mellon University) and Ted Tschang of Carnegie Mellon University on the geographic distribution of the burdens on households of the proposed Btu tax. He also compared the reductions in emissions of carbon dioxide that would be obtained from that tax with the reductions that might be expected to result from a carbon tax generating the same amount of revenue. The analysis, which was based on 1987 estimates of household energy consumption in each of the nine U.S. Census regions, revealed that nationally households would pay an average annual Btu tax of $114 dollars over the short run (the first one to three years after imposition of the tax). Households in the Middle Atlantic region would pay the lowest tax ($102 per year), and households in the Mountain region would pay the highest tax ($130 per year). Over the long run, the average annual Btu tax would drop to $104, with households

in the Middle Atlantic region paying only $93 per year and those in the West North Central and Mountain regions paying $117. The Btu tax would reduce carbon emissions by 3.7 million tons over the short run and by 43.8 million tons over the long run. In comparison, a carbon tax would be slightly less evenly distributed than the Btu tax. Over the long run, it would reduce only about 4 million tons more carbon emissions than the Btu tax.

Margaret A. Walls, fellow in the Energy and Natural Resources Division at RFF, and Alan J. Krupnick, senior fellow in the Quality of the Environment Division at RFF, discussed research they conducted with Carter Hood, a research assistant in the latter division, on that portion of the proposed energy tax that would fall on gasoline. Walls focused on how an increase in the gasoline tax of 7.6 cents per gallon would have affected households if it had been imposed in 1990. She reported that the increase would have resulted in an annual revenue increase of $7.47 billion and would have reduced average vehicle miles traveled (VMTs) per vehicle by 421 miles (3.31 percent), total VMT by 67.2 billion miles, and consumption of gasoline by 3.4 billion gallons (3.34 percent). She noted that the burden of the tax increase would have hit rural areas the hardest: rural areas would have faced an average annual tax per household of $99, as compared with $85 for suburban areas and $79 for urban areas. Moreover, Walls reported that the tax would have been regressive. Households with incomes of less than $27,500 (which comprised 47.3 percent of all U.S. households in 1990) would have borne 29.7 percent of the tax burden, while households with incomes greater than $77,500 (which comprised 6.9 percent of all U.S. households in 1990) would have borne 11.9 percent of the tax burden. For the former, the gasoline tax increase would

have amounted to 0.34 percent of household income; for the latter, it would have amounted to only 0.13 percent of household income.

Krupnick discussed how the gasoline tax increase would have affected emissions of both volatile organic compounds (VOCs) and nitrogen oxide (NOx) in 1990. He reported that the tax would have reduced total emissions of VOCs by 173,000 tons and total emissions of NOx by 182,000 tons. This would have been a reduction of less than 1 percent for each pollutant.

Krupnick also discussed how the gasoline tax increase would have affected VOC emissions in New York City if it had been imposed in 1990. He began by noting that the Clean Air Act (CAA) requires the city to decrease VOC emissions by 15 percent of 1990

levels by 1996. In the summer of 1990, a total of 1,047 tons of VOCs were emitted each day. Nearly half of the VOCs—443 tons—were emitted by automobiles and light-duty trucks. To meet CAA requirements, the city would have to reduce VOC emissions by 159 tons on each summer day. The estimated reduction in VOC emissions from vehicles resulting from a 7.6 cent increase in the gasoline tax would be 12 tons on each summer day. Thus the increase in the gasoline tax would allow the city to achieve 7.5 percent of the VOC emissions reduction required by CAA. Krupnick found, however, that the VOC reduction would not have moved New York City toward attainment of the national ambient ozone standard of .12 parts per million (ppm). He estimated that the city's

peak ozone concentration in 1990 would have fallen from .16 ppm to .157 ppm as a result of the increase in the gasoline tax.

Krupnick noted that the social cost of the gasoline tax increase would be lower than that of several alternative ways to achieve reductions in VOC emissions. He calculated that the social cost per ton of VOCs reduced as a result of the increase would be $624. By comparison, enhanced vehicle inspection and maintenance programs and early vehicle retirement programs would each reduce VOC emissions at a social cost of $3,000 to $5,000 per ton. Substitution of reformulated gasoline for conventional gasoline would reduce VOC emissions at a social cost of $3,000 per ton and use of vehicles that run on methanol at a cost of $30,000 per ton.

# RFF cosponsors journalists' seminar on the environment

Resources for the Future (RFF) and the National Press Foundation, a nonprofit group that works to improve journalism, sponsored a seminar on the environment on May 23 through May 26. Fifteen reporters from newspapers, magazines, and newsletters published in the United States were selected on a competitive basis to attend the seminar, which featured talks on a variety of environmental issues by representatives of government, environmental groups, the academic community, and industry. Among the speakers were Katherine N. Probst, fellow in the Center for Risk Management at RFF, and Paul R. Portney, vice president of and a senior fellow at RFF. Probst discussed the cleanup of hazardous waste under the Superfund program; Portney participated in a panel discussion on the Clean Air Act. Kathleen A. McGinty, director of the White House Office on Environmental Policy, was the guest speaker at
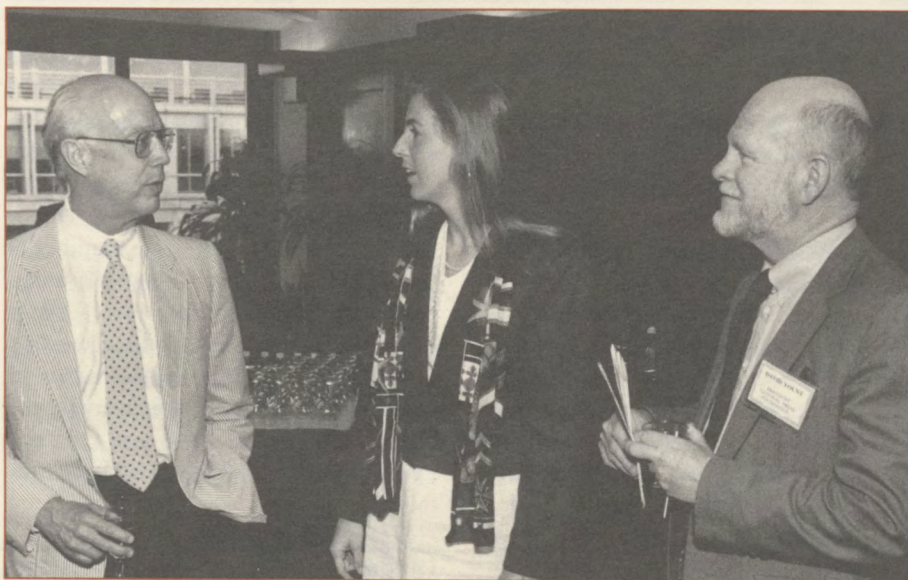


At a dinner for reporters attending the RFF–National Press Foundation seminar on the environment, RFF president Robert W. Fri (left) and National Press Foundation president David Yount (right) discussed the Clinton administration's stand on various environmental issues with Kathleen A. McGinty, director of the White House Office on Environmental Policy.

a dinner for the reporters at the National Press Club.

The aims of the journalists' seminar were to help reporters outside of the Washington metropolitan area to get a good grasp of environmental issues and

policy alternatives and to establish working relationships with environmental, scientific, government, and economic experts in Washington, D.C. RFF and the National Press Foundation hope to make the seminar an annual event.

## RFF researchers visit Ukraine

As part of RFF's continuing effort to develop a long-term program of collaborative research, policy advice, education, and institution-building in Ukraine, three senior fellows in the Energy and Natural Resources Division at Resources for the Future (RFF) met with representatives of government agencies and research organizations in Ukraine from May 5 through May 13. During their nine-day visit, division director Douglas R. Bohi, Molly K. Macauley, and Michael A. Toman made contacts with high-ranking officials in the Kiev Research Institute for Socioeconomic Problems; the National Space Agency, National Ecological Center, Environmental Education and Information Center, and Ministry of Environment in Ukraine; and the Institute of Energy Saving Problems and the Institute of Electrodynamics at the Ukrainian Academy of Sciences. Funding for their trip was provided by the Trust for Mutual Understanding, a private U.S. foundation.

At a seminar in Kiev on environmental economics for experts at the Ministry of Environment, the RFF scholars provided overviews of natural resource valuation, externalities, and the use of economic incentives to protect the environment in general and to regulate toxic substances in particular. They also surveyed the close connections between environmental protection and economic restructuring. The discussion period following the seminar—which was hosted by Juriy Ruban, a Ukrainian exchange scholar who visited RFF in 1992 and who now serves as deputy minister for the Ministry—revealed Ukraine's desperate need for basic information about how to approach environmental monitoring and regulation.

During the visit to Ukraine, Bohi participated in an international conference on energy issues in Ukraine and Russia that was organized by the Atlantic Council of the United States, hosted by the Ukrainian Academy of Sciences, and attended by experts from the United States and Japan, as well as from Russia and Ukraine. While much of the conference emphasized the need to move energy prices to market levels, Bohi noted that the economic and environmental benefits of a policy to meet that need cannot be effectively realized unless Ukraine and Russia are successful in restructuring their economies to establish an effective market system. He suggested that the establishment of such a system would involve the institution of a more effective private property system than is now in place; demilitarization; restructuring of state enterprises; reduction of obstacles to domestic and foreign investment; and formulation of stable macroeconomic policies, including policies to control inflation.

While in Kiev, Toman and Macauley met with several Ukrainian organizations that could potentially contribute to the long-term program that RFF is seeking to establish in Ukraine. Their meeting with the International Renaissance Foundation, a private philanthropic organization, resulted in the foundation's offer to coordinate professional education programs to be conducted in collaboration with the Ministry of Environment. In addition, Toman and Macauley made or strengthened contacts with a number of individual scholars and institutions that could potentially join RFF researchers in

## Four new directors elected to the RFF board

Anthony S. Earl, Linda G. Stuntz, Linda C. Taliaferro, and Victoria J. Tschinkel were elected to the board of directors of Resources for the Future in April. Earl is a partner in the Quarles & Brady law firm in Madison, Wisconsin. Formerly governor of Wisconsin and secretary of the Wisconsin State Department of Natural Resources, he is the co-founder and chairman of the Center for Clean Air Policy, a board member of both the Center for the Great Lakes and the Great Lakes Protection Fund, and a member of the governing board of Common Cause.

Stuntz is a partner in the Van Ness, Feldman & Curtis law firm in Washington, D.C., and a member of both the District of Columbia Bar Association and the board of advisers for the *Harvard Environmental Law Review*. She formerly served as deputy secretary of energy at the U.S. Department of Energy; deputy under secretary for policy, planning, and analysis; acting assistant secretary for domestic and international energy policy; and acting assistant secretary for fossil energy.

Taliaferro, of the law firm Taliaferro and Associates in Philadelphia, Pennsylvania, is an ex-officio member of the National Association of Regulatory Utility Commissioners, a life member of the Washington Urban League, a member of the board of directors of Orange & Rockland Utilities; and a founding member of the American Association of Blacks in Energy. She was formerly the commissioner and the chair of the Pennsylvania Public Utility Commission.

Tschinkel is a senior consultant with Landers and Parsons in Tallahassee, Florida; director of both the Environmental Energy Study Institute and the German Marshall Fund of the United States; commissioner of the National Commission on the Environment; a member of the University of Chicago Board of Governors for the Argonne National Laboratory; and chair of the Gas Research Institute Advisory Council. She was formerly secretary of the Florida Department of Environmental Regulation.

studying Ukraine's economic and resource management problems. They also established contacts with individuals working at the U.S. Agency for International Development mission office in Kiev.

During the latter part of their visit, Macauley and Toman met with senior officials in the Ukrainian National Space Agency and with scientists associated with Ukraine's space program. Discussions with these individuals yielded information about such future activities in the Ukrainian space program as the manufacture of launch vehicles and the upgrading of remote sensing capabilities.

The RFF scholars' visit concluded with a meeting with the deputy economics minister in charge of basic industries and other senior cabinet officials to discuss energy pricing and economic restructuring. During the meeting,

Toman reemphasized the need for market energy pricing, provided such pricing is coupled with wider economic reforms.

While the majority of their time was spent in Kiev, the RFF scholars also visited the L'viv region in western Ukraine as guests of Zinoviy Drevnyak, another RFF exchange scholar who is secretary of state for the region. During their two-day stay in L'viv, the scholars were given a tour of the Carpathian Mountain region and information on efforts to exploit sustainably the region's forest and other resources.

The RFF scholars have been invited to return to Ukraine for further consultations, suggesting that a number of Ukrainian policymakers view RFF as a useful participant in efforts to restructure the Ukrainian economy and to reform Ukraine's environmental policies.

## Gilbert F. White fellows selected

Resources for the Future has awarded Gilbert F. White postdoctoral fellowships for the 1993–1994 academic year to Seema Arora, Barbara J. Kanninen, and Daniel Sperling. Arora, who is completing her Ph.D. in the Department of Economics at the University of Southern California, will be conducting research on why regulated firms often reduce pollution by amounts greater than required. Kanninen, an assistant professor of environmental economics and policy at the

Hubert Humphrey Institute of Public Affairs at the University of Minnesota, will conduct research on the cost-effectiveness of technological enhancements that would permit improved vehicle flow and traffic safety on highways. Sperling, director of the Institute of Transportation Studies at the University of California-Davis, will research a book dealing with the future of urban passenger transportation, with particular attention given to motor vehicles.

## RFF awards nearly $50,000 in grants

Resources for the Future has awarded nearly $50,000 in research grants to individuals at two universities. The awards were made through the RFF Small Grants Program, which provides financial support to researchers at universities and other nonprofit institutions in the United States and abroad to study issues related to the environment, natural resources, and energy.

This year, RFF awarded a $29,408 grant to Glenn Harrison of the University of South Carolina for research on validating the contingent valuation method with statistical bias functions, and a $19,470 grant to Dean Lueck of Louisiana State University for a study of conservation regulation that deals with reservoir-wide utilization and large-tract leasing of oil and gas in Louisiana.

## Joseph L. Fisher Dissertation award winners announced

Resources for the Future (RFF) recently announced the winners of the Joseph L. Fisher Dissertation awards, which are given to students in economics and social science disciplines to support their final year of graduate study. To be eligible for the awards, students must be writing dissertations on natural resource or environmental issues. The following individuals each received $12,000 fellowships in support of the completion of the dissertations indicated:

• J. Andres Espinosa, Department of Agricultural and Resource Economics, North Carolina State University: "Consistent General Equilibrium Measurement of the Net Benefits of Improving Environmental Quality."

• Carol Mansfield, Department of Economics, University of Maryland: "Despairing Over Disparities: Testing Hypotheses on the Difference Between Willingness to Pay and Willingness to Accept."

• Janusz Mrozek, Department of Economics, Stanford University: "A Theoretical and Empirical Analysis of Tax-Rebate Methods for Emissions Control."

• Craig Thomas, Department of Political Science, University of California: "Interagency Cooperation and the Management of Biodiversity."

The large number of solid dissertation proposals submitted in 1993, the first year of competition for the Joseph L. Fisher Dissertation awards, was impressive, according to RFF senior fellow and vice president Paul R. Portney. Portney noted that RFF hopes to double the number of awards given in the future.

# Discussion papers

RFF discussion papers convey the preliminary findings of research projects for the purpose of critical comment and evaluation. Unedited and unreviewed, they are available at modest cost to interested members of the research and policy communities. Price includes postage and handling. Prepayment is required. To order discussion papers, please send a written request, accompanied by a check, to Discussion Papers, External Affairs, Resources for the Future, 1616 P Street, NW, Washington, DC 20036-1400.

The following papers have recently been released.

### Energy and Natural Resources Division

• "Issues and Proposals for Environmental Liability Reform in Central and Eastern Europe," by James Boyd. (ENR93-09) $5.00

• "Losses from the Complete Merger of First Movers," by Stephen W. Salant and Gerard Guadet. (ENR93-10) $5.00

• "Government Gold Sales: Quantifying the Welfare Effects with a Calibrated Model," by Stephen W. Salant, Dale Henderson, and John Irons. (ENR93-11) $5.00

• "Taxing Variable Cost: Environmental Regulation As Industrial Policy," by David R. Simpson. (ENR93-12) $5.00

"Common Law and Market-Based Incentives for Toxic Substances Labeling," by James Boyd. (ENR93-13) $5.00

• "Economic Theory and 'Sustainability,'" by Jeffrey Krautkraemer, John Pezzey, and Michael A. Toman. (ENR93-14) $5.00

• "Nonrenewable Resource Supply: Theory and Practice," by Michael A. Toman and Margaret A. Walls. (ENR93-15) $5.00

### Quality of the Environment Division

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