Green taxes, blue taxes

A comparative study of the use of fiscal policy to promote environmental quality

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Central governments are facing increasingly stringent demands to lead the clean-up of public resources. Historically, governments have chosen legislation and regulation to address these concerns and achieved mixed results, but another tool of public policy holds significant promise and is gaining ground in the policy debate: 'green' taxes. The potential of a tax system to mitigate environmental externalities is explored. The theory of pollution tax is reviewed and a comparison of two country cases where taxes have been designed explicitly to reduce industrial effluents and improve the quality of fresh water resources is presented. If structures to approximate social costs are federally mandated and regionally implemented, a comprehensive tax system can constitute an integral part of an effective response to private spoliation of the commons.

The Soviet Academy of Sciences recently held an international conference to discuss the future of the Danube and the role which developed and developing European nations can play in the river's recovery ([13], p A1). As West Germany and its eastern neighbours have industrialized, the Danube has turned from a brilliant romantic blue to a sludgy brown. This international waterway is now acknowledged to represent one of the worst polluters of the Black Sea, as it collects urban and industrial refuse in the form of pesticides, fertilizers, chemical run-off and human waste throughout the 2000 miles of its course from the Black Forest in West Germany to the Black Sea off the coast of Rumania.

What are the possible responses of those central governments responsible for the Danube to the pollution of this public resource by private and semi-private industry? As the guardian and allocator of public goods, the government is beholden to respond in some way, but the most effective policy to choose has never been clear. One tool which has been brandished with some regularity and some effectiveness in the Western countries, is regulation, an option which relies on the legislative function of government to express the wishes of the voters in the protection of common resources. Another has been to rely on the court system to adjudicate claims by victims directly affected by the spoliation by industry of the environment, a method employed with greater net effect in Japan than in the USA or Western Europe [14]. A third option, espoused with great eloquence by the academic community but seldom employed anywhere, is the direct use of fiscal measures to reduce pollution: taxes.

The taxation dilemma

Legislators and chief executives find taxes odious and the reason is obvious: taxes are, by definition, punitive and anti-growth. Regulation may also be claimed to be anti-growth, but certainly seems less objectionable than taxes: protective standard-setting may be

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waved like a flag of consumer advocacy. Taxes, especially in the last 20 years in market economy countries, have suffered an increasingly poor reputation as the vice of big, inefficient government and the enemy of free enterprise.

In some countries, however, especially those most concerned with the state of their physical environment, the option to tax is being exercised with greater frequency as a method of reducing pollutants. In August 1990, in Sweden, for example, the government introduced a SKr30 ($5) value-added tax on each kilo of industrial sulphur emissions [16]. Norway, the Netherlands and Japan have had sulphur emission charges in place for some time [9], but Sweden also plans to implement what the Swedes call Europe's first carbon tax – SKr0.025/kilo – as well as taxes on nitrous oxides [16]. Of course, Sweden has long been comparatively progressive in environmental measures: the government plans to phase out nuclear energy sources by 2010 and maintain hydroelectricity generation at current levels.

The fact is that the pollution tax scheme is sweeping Western Europe. Norway's 1991 budget includes a tax on the emissions of chlorofluorocarbons (CFCs) [16]. Finland introduced a carbon tax in January based on the carbon content of fossil fuels, equivalent to $6.10/ton of emission [16]. The campaign platform of Oskar Lafontaine for West German chancellor included replacing the revenue from income tax cuts with a tax on oil. The government of the Netherlands is considering levying tariffs on pesticides, fertilizers and manure and the Dutch cabinet proposed in November 1989 that increased taxes on carbon emissions be used to provide funds for environmental clean-up programmes [16]. In 1989, Italy placed an 8¢ tax on all plastic bags sold and the cabinet has approved a tax package which targets a wide range of culprits ranging from sulphur dioxide producing industry to pig farms unequipped with waste-treatment facilities. This plan, like the Netherlands', is designed to increase revenues and Italian economists estimate that 1.5×10^{12} lire, or $1.2 billion, could be raised by the package. Green tax proposals also are being considered in France, Ireland, Belgium and even Britain.

The degree to which a tax will raise revenue, instead of changing behaviour, is the degree to which it fails to really serve as a 'green' tax and becomes a new resource for government spending.[1] The effectiveness of a tax designed to reduce pollution, rather than raise revenue, is a direct result of the elasticity of demand for the offending product or activity. Here springs the continuing debate on the efficacy of a petrol tax in the USA and worldwide as an effective weapon against global warming: a tax high enough to curb driving or to promote greater gas efficiency in new models is also high enough to damage national economic growth and further harm US productivity.

Rather than become embroiled in such a debate, the following analysis will focus on the track record of taxation as a policy designed to reduce pollution *per se*, rather than raise revenue. In this regard, it is worth examining any cases which exist involving the explicit levying of tariffs on a per-unit-of-effluent basis in an attempt to measure the efficacy of the tax option as a pollution abatement scheme. The purpose is not to compare taxation with regulation, nor to limit the study to particular political and institutional parameters (although such parameters are clearly crucial in the formation and implementation of policy), but rather to analyse the actual results of taxation policy in two comparable country cases.

What is perhaps most remarkable about this analysis is the dearth of cases to be analysed: until the recent spate of laws described above, few countries exercised their national power to levy taxes in the reduction of pollution, despite the plethora of theoretical literature espousing the potential benefits of taxation.[2] In perhaps the only cross-country comparison of its kind, Craig Reese [10] concludes that across the six developed Western countries perhaps most inclined to use pollution taxes as a weapon against pollution – Canada, France, West Germany, Sweden, the UK and the USA – 'there have been no comprehensive uses of them' ([10], p 414). Reese's study is one of tax policy defined broadly to include all sorts of tax incentives and revenue enhancement measures and thus despite his conclusion on 'punitive' taxes – those designed to reduce pollution rather than encourage conservation or raise funds for environmental programmes – he has plenty of fodder for his book.[3] The type of tax policy analysed here will have a narrower definition: those pollution taxes explicitly designed to reduce effluents.

[1]Rees notes in this regard that user charges for disposal of household solid waste have been at the forefront of policy designed to generate abatement rather than revenue in the USA, France, Sweden and West Germany. See Environmental Protection Agency [5] and K. L. Wertz [15].

[2]Many of the articles date back several decades. See for example, Harold Hotelling [6], Francis M. Bator [1], William J. Baumol [2], Leonard A. Shabman and Oral Capps [11], Michael A. Brooks and Ben J. Heidra [4] and Charles Plourde and David Yeung [8].

[3]Other tax systems not discussed here but worth examination include royalty or severance taxes on production of natural resources. See for a theoretical examination of this type of tax scheme, Rees [9], pp 194–201. For a strong case study on the topic see T. V. Sairam [12]. The case concerns the imposition of custom duties rates on the Indian timber industry to control deforestation. The author concludes that the tax structure has generated only limited success since it fails to force the timber industry to internalize reforestation costs.

Despite Reese's assertion, examples exist of limited measures taken in this regard at a central government level. The cases selected for examination here are the Netherlands and West Germany. Both countries are open, developed market economy countries with comparable per capita incomes and high population densities. The Federal Republic of Germany in 1987 produced a GNP per capita of $14 400 and had 246 people/km^2. The Netherlands' GNP per capita in 1987 totalled $11 860 and an average of 397 people/km^2 [17]. Both cases involve the levying of taxes on organic industrial discharges into freshwater resources. Both cases offer the opportunity for analysis over a long-term period, ie greater than 10 years. Finally, both countries possess relatively reliable data sources. West Germany, in an effort to reduce wastewater pollutants, initiated the *Genossenschaften*, or water-quality associations, in 1913. Federal law requires membership in the associations of all firms discharging any material into a given water basin; one major activity of the associations is the levying of a per-unit-of-effluent fee to all members. Additionally in 1976, West Germany passed the Waste Water Charges Act (WWCA), in an effort to improve water quality through the direct federal taxation of industry. The Netherlands passed legislation predating the WWCA, but quite similar to it in both form and intent, in the Pollution of Surface Waters Act of 1970. The Act prohibits direct discharge of organic material into surface waters without a license and levies a flat charge on a per-unit-of-effluent basis equivalent to the amount of organic matter produced by one person per day.

Before examining the cases in greater detail, however, it is necessary to review briefly the underlying theory behind pollutant-reducing taxation.

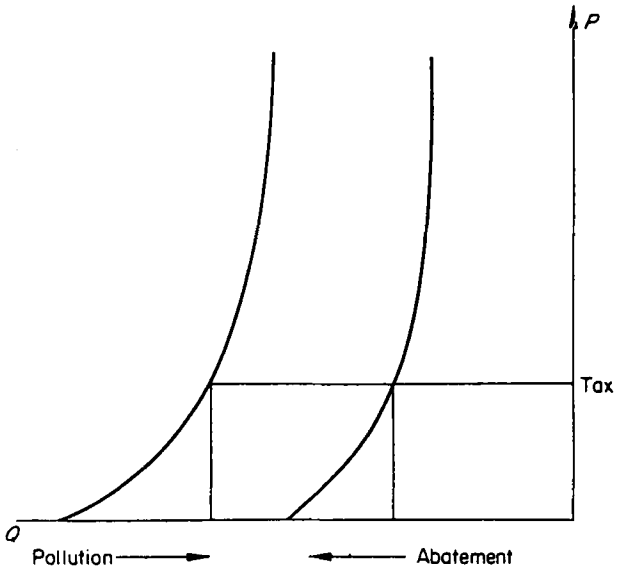

Figure 1. As production at two firms increases, pollution increases A tax imposed on pollution on a per unit of effluent basis will curtail production to the point at which the marginal cost of pollution abatement, shown increasing with pollution, exactly equals the marginal benefit of pollution abatement, the tax saved.

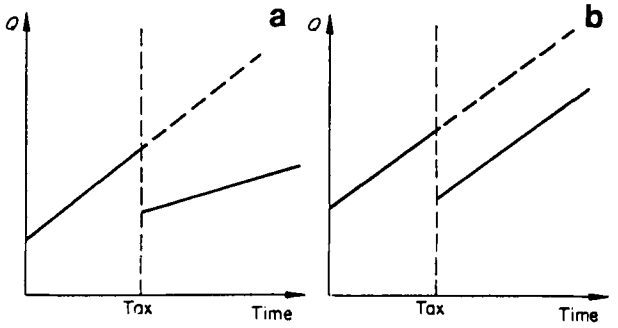

Figure 2. Long range effect of pollution abatement tax and technology.

The theory

Although specialized theories abound to explain and predict the behaviour of individual firms in response to taxes, general microeconomic theory describes the situation as it is depicted in Figure 1. A per-unit-of-effluent tax, levied on two firms, will reduce the effluent of each until the marginal cost of abatement equals the marginal benefit of avoiding the tax. In lay terms, each firm will reduce pollution only until the cost of avoiding the last unit of pollution equals the amount of the tax, at which point the firms will revert back to the pollution option since the marginal cost of pollution abatement will continue to rise even as the tax remains the same.

In the short run, net pollution will decrease since both firms cut effluents proportionally to levels of production. The long run is unclear: if the pollution abatement technology actually reduces the rate of increase of effluents as well as the marginal effluent of production, the long-run gains will increase compared to a non-tax situation (Figure 2a). If the technology does not affect the rate of increase on a per product level, then the long-term benefit of the tax amounts to zero since the reduction in effluents only delays the inevitable spoliation of the environment by ever-increasing production (Figure 2b).

From the firm's standpoint, such a tax is considered undesirable, inasmuch as it increases marginal costs of production, but equitable, because both large producers and small producers pay proportionally: every firm retains its place in the market. In this sense, tax is preferable to regulation because standard-setting tends to affect the cost structures of large producers before small ones.

The case studies

West Germany

Water pollution in the Federal Republic of Germany began to pose extreme risks in the wake of the post-war industrial and economic growth which established West Germany as an economic power in the European Community. The hardest hit areas of the nation are the industrial regions in the Ruhr surrounding Berlin, Hamburg, Munich, Cologne and Frankfurt. Major sources of water pollution include the chemical industry, the iron and steel industries and household sewage. Between 1949 and 1970, the Rhine river's contamination increased twentyfold; several tributaries of the Rhine were biologically dead ([10], p 139). Much of the political momentum generated in the 1970s in support of environmentalism grew from the sudden death of millions of fish in the Rhine following the routine dumping of chemicals in the summer of 1969.

Despite the creation after that disaster of a federal environmental office, modelled after the US EPA, the German Constitution limits federal authority with regard to water pollution to 'framework competence', ([10], p 147) leaving primary jurisdictional power to individual states. The *Genossenschaften* are quasi-public bodies. Granted broad authority by state and federal governments, their main purposes is to integrate state water quality principles, determine policy with respect to all member firms, which whether public or private are required to join the association if they discharge any materials into the basin which defines the *Genossenschaft's* jurisdiction, and install and operate water quality programmes. The programmes include treatment facilities, systems to improve oxygenation and flow and taxation programmes which ultimately support the *Genossenschaft's* operations. The effluent tax is a flat charge calculated on the basis of an estimation of the damaging effect of the discharger's wastewater and thus is intended to approximate the social damage cost of the pollution. Monitoring of discharge is accomplished through relatively simple means of measurement; according to analysts, the mechanism to resolve disputes over discharge figures have worked well, in part because the monitoring agency – the *Genossenshaft* – is an organization of like-minded industries, rather than a third party regulatory governmental agency ([10], p 151). The organizations meet at least once annually; voting power is in direct proportion to wastewater generated, 'allegedly [to] guard . . . against the incurring of unnecessary expenditures for wastewater treatment' ([10], p 152).

West Germany imposed additional effluent taxes through the passage of the Waste Water Charges Act of 1976 (WWCA), a law which took effect on 1 January 1978 generating taxes as of 1 January 1981. As with the *Genossenschaften*, the water pollution taxes imposed by the federal programme levy the tax on a per unit basis of noxiousness of wastewater, corrected for local urban populations and rainwater runoff on the folowing graduated schedule: as of 1/1/81: DM 12; as of 1/1/82: DM 18; as of 1/1/83: DM 24; as of 1/1/84: DM 30; as of 1/1/85: DM 36; and as of 1/1/86 DM 40. The DM 40 figure was intended to approximate the marginal cost of wastewater treatment with 90% efficiency, reflecting the federal government's stated goal of improving water quality to 90% of desired quality levels. Ironically, the increases in rates decline annually from a high of 50% in the first year to a low of 10% in the final year. Still, the graduated increases approximate the actual social cost of the pollution emitted by each firm more accurately than any previous pollution taxation systems.

Penalties for non-compliance with the WWCA, through either failure to submit data as required by the law or failure to comply with the measuring criteria stipulated amount to fines not exceeding DM 5000 and liability under existing German law. It is worth noting that the WWCA does not address two very pressing water pollution issues that Germany faces: supply and quality of groundwater and the condition of the North Sea bordering the German coast.

The best measure of whether the system has 'worked', either in the case of the *Genossenschaften* or with the WWCA is in the examination of the river water quality[5] over the period in which these measures have been in place (Tables 1 and 2). The data indicate that both under the *Genossenschaften* (1970 and previously, on) and the WWCA (1981 on), river water quality has improved across a number of indices. The Rhine clearly shows the greatest improvement over the time period, with dissolved oxygen increasing by 66% and BOD decreasing by 38%. Mineral levels from industrial discharge have decreased even more dramatically: cadmium has dropped 87.5% and chromium has dropped 75%. The greatest problem area remains in the runoff of fertilizer residue. Despite declining oxygen demand, indicating that algae blooms have abated somewhat, phosphorus concentrations have fluctuated and nitrate levels have increased over the 20 year period.

[4]Federal Waste Water Charges Act, Article 9, paragraph 3, cited in Reese [10], p 189.

[5] The *Genossenschaften* and the WWCA were not targeted to river water exclusively, but the only major lake at issue for West Germany is Lake Constance, the borders – and spoliation – of which the Federal Republic shares with Austria and Switzerland. Given water movements, it would be unreasonable therefore to conclude that any change or lack of change in the quality of Lake Constance would be due to German law alone.

Table 1. River water quality 1970–85.

	Rhine-Bimmen L	Elbe	Vesdre	Danube-Jochenstein
Dissolved O_2 (mg/l)				
1970	5.6	n/a	n/a	10.5
1975	6.8	n/a	9.4	10.3
1980	9.0	9.0	8.6	10.6
1985	9.3	8.1	8.7	10.5
BOD (mg/l)				
1970	6.1	n/a	n/a	4.8
1975	7.9	n/a	n/a	3.1
1980	4.0	6.2	5.4	3.1
1985	3.8	8.6	4.3	3.2
Nitrate (mg/l)				
1970	1.82	n/a	n/a	0.20
1975	3.02	n/a	4.30	0.30
1980	3.59	3.90	5.42	0.50
1985	4.20	2.99	5.08	0.60
Phosphorus (mg/l)				
1970	0.52	n/a	n/a	n/a
1975	0.75	n/a	0.67	n/a
1980	0.36	0.36	0.53	0.18
1985	0.48	0.53	0.36	0.21

Source: World Resources 1988–89.

Table 2. River water quality 1970–85.

	Rhine-Bimmen L	Elbe	Vesdre	Danube-Jochenstein
Lead(μg/l)				
1970	n/a	n/a	n/a	n/a
1975	24	n/a	n/a	n/a
1980	7	n/a	2.0	n/a
1985	11	n/a	2.8	2.60
Cadmium (μg/l)				
1970	n/a	n/a	n/a	n/a
1975	2.40	n/a	n/a	n/a
1980	1.40	n/a	0.50	0.20
1985	0.30	n/a	0.50	0.10
Chromium (μg/l)				
1970	n/a	n/a	n/a	n/a
1975	40	n/a	n/a	n/a
1980	22.3	n/a	3.00	n/a
1985	10	n/a	3.00	n/a
Copper (μg/l)				
1970	n/a	n/a	n/a	n/a
1975	24	n/a	n/a	n/a
1980	19.9	n/a	5.60	n/a
1985	13	n/a	9.20	n/a

Source: World Resources 1988–89.

Data for the other three rivers is inconclusive, but the indication for the 1980–85 period seems to be in the direction of improvement, given the figures for oxygen demand decreases in the Vesdre, and the reduction of nitrate concentrations in the Elbe and Vesdre.

From the data, several conclusions are possible. First, whether conditions have improved varies from region to region. Second, those rivers of particularly poor quality in 1970 tend to have improved the most by 1985: the Rhine, measured in the region of Bimmen, shows significant improvement across all areas except nitrates (the data on phosphorus levels is inconclusive). Sadly, the Danube remains in an extremely serious state, although its current state in West Germany is far better than either the condition of other German rivers or the condition of the Danube itself further downstream as it enters Eastern Europe ([13], p A6).

Third, although no data exists describing water quality in these areas prior to 1970, the degree to which the Rhine and other rivers exhibit significant damage indicates that the *Genossenschaften* may well have been a less effective solution to a pollution control through taxation than the WWCA system of graduated effluent charges. How much less effective is impossible to measure given the uncertainty emanating from (i) measures which individual companies may have taken to reduce or increase emissions independent of the local *Genossenschaft* or the WWCA, (ii) the degree to which the *Genossenschaften* initiated positive changes extant in improvements in the 1970s, which the WWCA enhanced; and (iii) ambient water quality.

Finally, and most importantly, it is possible to conclude that even given regional differences in policy implementation, the taxation of effluents can work to significantly improve regional water quality. A more extensive policy analysis follows the Netherlands example.

The Netherlands

The charges to be analysed in the Dutch example stemmed from the Pollution of Surface Waters Act of 1970 (PWSA), which prohibits all direct discharges into surface waters without a license ([3], pp 143-168). As with the West German legislation, the main revenue feature is not the non-compliance sanction of the permit system (which in both cases seems to serve primarily as a negotiating tool), but a graduated system of charges levied on a per-unit-of effluent basis. In the Netherlands, the charge amounted to $4 per inhabitant equivalent (ie an amount equal to the effluent generated by one person) and had climbed to $15–20 by 1983. The charge structure therefore is similar in form and severity to that of the WWCA.

The purpose of the charge system was also similar to that of the WWCA in that the main goal was pollution reduction rather than revenue generation. This stated goal of the 1970 legislation is in keeping with the stand-still principle of much of Dutch environmental policy – that is the goal is 'reducing the total extent of existing pollution, by both dealing with particular problem areas and preserving as much as possible the present level of environmental quality in relatively unpolluted areas ([3], p 144). As with the *Genossenschaften*, any revenue generated by the taxes levied was circulated back into the budget allocated for improving environmental quality at the regional levels. Finally, the policy was designed to promote the 'polluter pays' principle embodied in OECD international legislation and both versions of the German law.

In his analysis of the effect of the PWSA with respect to 14 branches of industry considered to be the main culprits in surface water pollution, Hans Bresser notes that discharge of organic pollution in the Netherlands declined 79% between 1969 and 1980 ([3], p 155) He analysed the data through a multiple regression technique by running actual effluent data (defined as level of abatement) against the following independent variables: factor of charge, cost of treatment and production increase. Under several analyses altering the periods examined, Bresser concludes that the charge factor has a strong positive impact on pollution abatement.[6]

In order to measure the effectiveness of the Dutch policy in relation to the German, it is necessary to compare cross-country data (Tables 3 and 4).

These data provide even greater evidence than the West German data that the effluent charge system has had a positive impact on river quality throughout the country. Dissolved oxygen has increased in three of four cases. Biological oxygen demand is down in all four cases, by as much as 74% in the case of the Meuse-Keisersveer. Mineral concentrations across the board have declined significantly: the most startling case is the Scheur-Maasluis, where lead concentration declined 85% between 1975 and 1985. The bad news remains in the area of fertilizer runoff, a chronic problem for the Netherlands as a developed nation whose exports are 26% primary commodities [17]. Nitrate levels have increased continuously during the period; phosphorus concentrations seem to have increased during the first decade and levelled off in the 1980s in all four cases.

Policy analysis

An analysis of the taxation policy as employed in the case of West Germany and the Netherlands necessitates examination of the policy formation and implementation process at four levels: institutional capacity and efficiency, policy design, behavioural effect of those at which the policy is aimed and physical effect on the environment.

Institutions

In both cases examined, institutions for the formation of policy lay fundamentally at the federal legislative

[6]Explained variance in the analysis of the entire 11 year period equaled 63% (R^2), with the following beta coefficients: factor of charge 0.61; cost of treatment -0.25, production increase -0.30. All beta coefficients proved to be statistically significant. For a subset of 12 industries, excluding small firms involved in stock-farming, and the starch industry (these were omitted for the possiblity that they would have a direct impact on the tested relationship), the charge factor became even more important as an explanatory factor. The beta coefficient in this case is 0.83 and $R^2 = 0.70$.

Table 3. River water quality 1970–85.

	Meuse-Keisersveer	Meuse-Eijsden	Scheur-Maasluis	Ijssel-Kampen
Dissolved O_2 (mg/l)				
1970	8.6	9.8	n/a	6.7
1975	9.4	9.5	7.1	6.7
1980	10.0	9.8	8.1	8.1
1985	9.7	8.1	9.3	8.2
BOD (mg/l)				
1970	6.2	4.1	n/a	5.7
1975	4.2	3.7	3.9	6.3
1980	2.3	2.8	2.2	3.9
1985	1.6	2.9	1.5	2.3
Nitrate (mg/l)				
1970	3.07	2.45	n/a	2.76
1975	3.69	2.51	3.37	3.46
1980	3.77	2.78	3.84	4.27
1985	4.28	2.92	4.16	4.33
Phosphorus (mg/l)				
1970	0.41	0.43	n/a	0.43
1975	0.57	0.73	0.56	0.62
1980	0.50	0.58	0.65	0.63
1985	0.48	0.57	0.55	0.57

Source: World Resources 1988–89.

Table 4. River water quality 1970–85.

	Meuse-Keisersveer	Meuse-Eijsden	Scheur-Maasluis	Ijssel-Kampen
Lead (μg/l)				
1970	n/a	n/a	n/a	n/a
1975	12	17	13	17
1980	12	23	11	9
1985	3.6	6.2	1.9	5
Cadmium (μg/l)				
1970	n/a	n/a	n/a	n/a
1975	0.90	3.10	1.00	1.40
1980	1.50	3.40	0.90	1.30
1985	0.21	0.35	0.26	0.40
Chromium (μg/l)				
1970	n/a	n/a	n/a	n/a
1975	7	14	16	25
1980	7	10	19	14
1985	3	6.4	5.3	7
Copper (μg/l)				
1970	n/a	n/a	n/a	26
1975	9	16	15	16
1980	12	11	12	9
1985	3.5	5.5	4.9	7

Source: World Resources 1988–89.

level. The *Genossenschaften*, WWCA and the PSWA were all national laws targeted at regional problems, contained within national boundaries.[7] In all cases, national parliamentary bodies designed policy solutions for environmental problems, and relegated implementation to regional councils. However, the autonomy granted to each regional authority, in relation to the federal authority exercised, varied considerably, and it is here that the main lessons in institutional development may be found.

In the case of the *Genossenschaften*, the federal

[7]It could be argued justifiably that river water quality of the Rhine and the Danube has international implications. This does not mitigate the fact that German industry is a major source of pollution of the Rhine and the German populace is a major user, making the issue a fundamentally domestic one for the sake of policy.

authority required only that all firms discharging into a particular basin become members. The local associations then took over all responsibility for establishing rates, administering charges and monitoring effluent levels. Moreover, the associations constituted nothing more than business clubs established for self-monitoring and regulation. By design, the *Genossenschaften* were prone to deal-making, which might be one reason that ambient pollution reached such dire levels by 1970. Whether the institution functioned well prior to post-World War II industrialization and only fell short in the face of significant increases in discharges during the 1950s and 1960s remains unclear in the absence of reliable long-term data. What is clear *de facto* is that the *Genossenschaften* were considered insufficient guardians of water quality by the German federal authorities, because the passage of the WWCA in 1976 required a stiffening of the charge structure and the implementation of what has been called the closest thing to 'an ideal pollution tax system wherein exactions are based on the damage of an amount of pollutant to society, that is, the marginal cost of specific amount and type of pollution' ([10], p 412). With the reform measures instituted by the WWCA, the federal authority subsumed much of the autonomy of the *Genossenschaften* and established national rates for discharges, leaving local authorities relatively little flexibility in administering them. The result of that effort has been mixed, with inconclusive data in three of four river water cases.

The Netherlands model represents a compromise position between local autonomy and central decision-making. There, the PSWA had clearly stated goals and methodology of the tax system, including a non-compliance clause, but left regional authorities to not only implement the rules but also set tax rates. It is difficult to make firm conclusions without greater detailed information on the nature of the regional authorities, but it is clear that the Netherlands tax system has had greater uniform success across regional river water examples. It may be inferred that a strong sense of mission and purpose from the central authority coupled with regional control constitutes the best recipe for success of a pollution taxation system.

Policy

The policy design as discussed above would seem to be crucial to its success. Key elements of both the WWCA and the PSWA include:

- The sanction for non-compliance is extant but peripheral to the action required under the law.
- The charges levied approximate the social cost of pollution on a per unit basis by levying a tax on a per unit of effluent basis.
- The tax system itself functions less as a punitive sanction for polluting (which would be the case were the purpose revenue enhancement and the price elasticity of demand a lot lower) than as an incentive to alter behaviour given changes in the internal cost structures of individual firms.
- The policy is comprehensive and flexible in that it includes effluents of all kinds, those known and unknown, and does not target and set standards for certain toxics at the point source.

On the negative side, it could be said that both the WWCA and PSWA tax systems fail to distinguish between more and less lethal poisons, thus inviting toxic substitution when the costs of clean-up of one substance are greater than the costs for another, more lethal substance of the same volume. Additionally, the tax systems do inspire preventive action on the part of individual firms, but by design fail to encourage zero-level discharge because companies will comply only until the cost of compliance is more than the cost of defiance: some discharge therefore remains profitable.

Any conclusions about the success of the tax systems are mitigated by the uncertainty stemming from at least three sources: change at the firm level, unrelated to the tax system in place, such as investment in new technologies which may increase or decrease the rate of discharge; regional or national developments which have an impact on the nature of the problem, such as new laws governing manufacturing inputs; and international sources of change, such as acid rain or the signing of treaties. In the West German example, for instance, the Federal Chemicals Law[8] was passed in 1980 to establish controls on the production, use and importation of new toxic chemicals. Whether the law had a direct impact on river water quality, and to what extent it mitigated or detracted from the effect of the taxation system, is impossible to measure.

Behavioural

Behavioural ramifications of the policy must be inferred from the physical data. It would seem that regional differences in compliance and policy implementation increase under a governmental system

[8]The law was also known as the Act on Protection Against Dangerous Substances and was enacted to comply with the European Community's Sixth Amendment to the 1967 Directive on the Classification Packaging and Labeling of Dangerous Substances. Debate over the law pitted the German chemical industry, Europe's largest, against environmentalist and the German labour unions.

characterized by greater local and regional autonomy in the face of high central authority and low central intervention at the implementation stage. Such a conclusion is possible, however, only in the presence of actual data describing discharge rates of individual companies and rates of revenue collection. Comparative data are not available, but it is known that revenues from the PSWA amounted to $20 million in 1971, one year after passage, $140 million in 1979 and $300 million in 1980, indicating that regional implementation of the policy was highly effective in encouraging firm compliance not only with the reduction of discharges but also with the payment of charges.

A behavioural analysis of the policy also introduces questions of the policy's impact on other sectors of the economy. For example, did the increased taxes generate unemployment, or affect inflation trends? Although a full analysis of the effect of the tax policies on the macroeconomies of West Germany and the Netherlands is impossible here, it is worth noting that a study published by the OECD in 1985 concludes that 'the macroeconomic effects of environmental policies are relatively small' [7]. While the study of six countries noted that increased pollution control systems generally had an indeterminate impact on production, exacerbated inflation, decreased unemployment and had greater short-term than long-term effects on the economy, all results fell in the range of a few tenths of a percentage point per year [7].

Physical

Clearly, the most important and the most encouraging result of this brief policy analysis lies at the physical level. Because the objective of the tax systems in each country case was pollution reduction, such significant improvement in water quality in the Rhine and in all four Dutch rivers indicates that the tax policy was successful. Bresser's regression analysis would seem to indicate that a causal relationship does exist between the physical improvements and the charge system. This conclusion, combined with the reduction in BOD, the increase in dissolved oxygen, and the reduction in mineral concentrations, indicates that the tax option is one which could contribute to an environmentally sustainable future, with economic growth. Implications for fertilizer run-off remain unclear.

Conclusion

The implications of this brief analysis for national policy outside of Western Europe can be summed up as follows. Where the effects of rapid industrialization are clear enough to inspire legal action, the option of a tax system should be considered as a viable alternative or complement to regulation, especially in cases where clear federal law may be implemented with some autonomy by regional authorities. Taxes would seem to be most effective as an anti-pollution policy tool when the price elasticity of demand is high, information is readily collectible, and rates approximate the marginal social cost of pollution. The study would seem to indicate that the European trend of 'green' taxes is right on track. It may be taxes that can best restore the Danube to its original beautiful blue.

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