Environmental Policy and Market Structure in the Federal Republic of Germany

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Goals and remedies of the German environmental policy for air, noise and water are described and analysed. A hypothesis of the effect on concentration is developed and tested.

I. Introduction

Following a review of the environmental situation the government has set up an environmental program in 1971. Federal laws were made possible by a modification of the constitution and were introduced later-on. Some are only frame-laws which can be filled up in detail by the states. This and the usage of many "unbestimmte Rechtsbegriffe" (undetermined definitions) give rise to some degree of uncertainty about the effects of these laws.

While there has been much discussion about environmental policy with respect to optimal allocation, the purpose of this paper is to analyse the effects of the existing laws on industrial structure. The German environmental policy will be outlined in Section III, after describing a basic model of environmental policy in Section II in order to give an orientation. Since the usual tools of economic policy are used only rarely, a translation into economic terms is necessary in many cases. In Section IV a basic model of the firm is engaged, to show the effects on firms. From this the consequences for market structure can be developed. The hypothesis of increasing concentration is tested in Section V.

II. Basis Model of Environmental Policy

For simplicity the production sector is taken as the single emission sector. The vector of goods X is produced and the vector of factors F^E is used for production and avoidance of emissions. A single pollutant E is emitted into the environment and transformed into immission I effective in the immission sector.

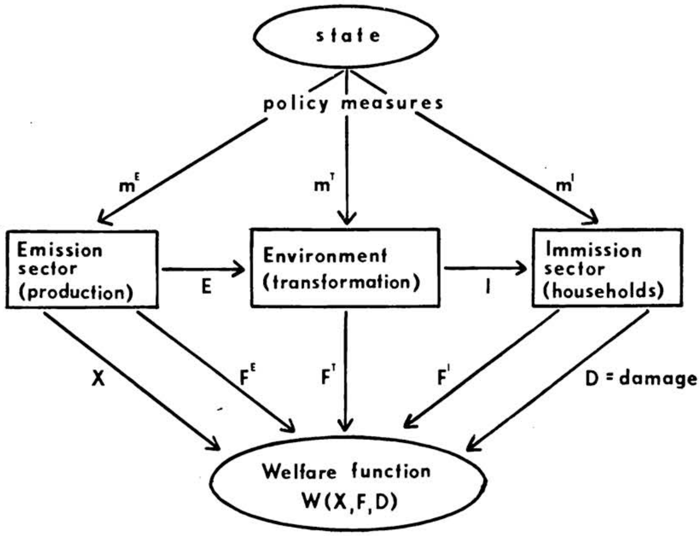


Fig. 1

The state can take policy measures in all sectors as e. g. emission standards or effluent charges in case of m^E, injection of air into water in case of m^T and installing noise curbing windows in case of m^I. All possible measures may be included. They normally involve costs by using factors F or by reducing goods X.

The three sectors can be described by models involving technical and behavioristic relations. The exogenous variables are the policy measures which are determining the endogenous variables of the sectors. So the reactions of firms and their customers to the policy measures are:

$$X = X^E\,(m^E) \tag{1}$$

$$E = E\,(m^E) \tag{2}$$

$$F^E = F^E\,(m^E) \tag{3}$$

The transformation of emission into immission is given by:

$$I = I\,(E, m^T) \tag{4}$$

$$F^T = F^T\,(E, m^T) \tag{5}$$

These functions become important when the space dimension is considered. E and I then have to be vectors for space elements. While there will be no factors used in the environment if the state doesn't take a measure here ($F^T = 0$ for $m^T = 0$) the households may use own and bought factors to avoid some damage which will add to those used for state measures. The reaction of the immission sector is given by:

$$F^I = F^I(I, m^I) \tag{6}$$

$$D = D(I, m^I) \tag{7}$$

D ist the remaining damage in physical units.

In pursuing environmental policy the state can try to maximize a welfare function

$$W = w(X, F, D) \tag{8}$$

by setting up an appropriate vector of policy measures. The conditions for the global maximum will not be analyzed in detail here. Usually a policy measure involves some costs as factor usage and production reduction and gives some benefits as damage reduction and the optimum would be at the point of equality of their marginal rates. In a global maximum some measures may have zero value even if they are non-zero for local maxima. This may stem from the fact that they are substitutive in character and one is more effective than the other.

III. Main Goals and Tools of German Environmental Policy

A. Air and Noise

The Bundesimmissionsschutzgesetz (Federal Immissions Control Act) came into effect on April 1st 1974. It protects against damaging effects by air pollution, noise, vibrations and similar processes. The main instrument is the authorization of equipment to be build or to be modified. For major equipment the authorization will be given on the condition that

1. there will be no damaging effects and considerable disadvantages to the public and the neighbourhood
2. emission curbing measures are taken according to best available technology (Stand der Technik)
3. waste discharges are recycled or disposed of orderly.

This is a simplified and uncomplete translation of § 5 Bundesimmissionsschutzgesetz. But in addition there is considerable uncertainty about the interpretation of the law. So the construction of a power plant by Steag in Voerde was delayed for several years because some people appealed against the authorization on the ground that the decree

TA Luft (technical instruction air) on which the administration had based its decision did not meet the requirements of the law. After a final decision of a federal court there is less uncertainty about the relevance of this decree now. What follows will be based on this detailed instruction which came out in 1974 and on the *TA* Lärm (technical instruction noise) which was issued in 1968.

According to *TA* Luft authorization will be given if

1. certain ambient standards in the affected region will not be exceeded
2. emission is avoided according to the best available technology or some specified emission standards
3. stack height is computed by a certain formula.

Point 2 and 3 have to be met in any case. If point 1 is in danger authorization can be made possible by

a) additional emission curbing measures

b) alteration of fuels, stack height or equipment dimension

c) diminution of emission of some other equipment of the firm in a limited period

d) diminution of emission by another firm which is determined to do so by a Luftreinhalteplan (clean air plan).

If existing equipment does not meet the standards the administration should give subsequent appropriate order. But this is a weak instrument since it can not be applied if firms are seriously affected economically. That is often the case because the design has to be changed completely. On the other hand firms themselves often wish to modify their equipment and for substantial modifications the strong rules have to be applied even if they imply high costs for meeting the standards. Hereby the administration is in a good bargaining position to make arrangements with the firms. Indeed as the German Council of Experts for the Environment has observed this is the most important instrument for improving existing equipment (Umweltgutachten 1978, Ziff. 1546). The arrangements may include prolongation of limited periods, tying of authorizations, abstention from fines etc. These measures may not all be quite legal but they may help the firms and the environment in the end.

The policy for noise reduction is similar to that of air purification described above. In both cases the emitting units have to meet emission rules in the form of specified standards or best available technology. The concept of best available technology may often be a function of costs and may be defined different by different parties therefore giving rise to disputes. The use fullness of this concept as a tool may further be questioned because the availability of better technologies may be affected. There is no incentive to develop a better technology with respect to purification if it is not better with respect to cost at the same time.

As long as ambient standards are fullfilled all emittants are treated equal according to the described rules and regardless wether the caused marginal demages are low or high. This implies a violation of the conditions of optimal allocation and is a consequence of the precautionary principle laid down in § 1 Bundesimmissionsschutzgesetz according to the described rules. When the border line of ambient standards is reached the emittants applying last have either to bear additional costs or to abstain from building or modifying a plant at that location. This too can be critized as violating optimality as *Siebert* does, who calls for a price mechanism to allot the allowed emission of a region to the emittants (*Siebert* 1977, pp. 36 - 40). A further instrument which is not equipped with an economic allocation mechanism is the Luftreinhalteplan (clean air plan). For heavy polluted areas (Belastungsgebiete) registers of emissions and immissions have to be established and a causal analysis for air pollution has to be done. Measures to diminish pollution have to be part of the plan but there is no order how they have to be determined. Luftreinhaltepläne are in a developing process yet. An economic allocation mechanism is not in sight.

Another instrument laid down in the Bundesimmissionsschutzgesetz are product standards. Series produced equipment may be subject to approval. Fuels and other materials must meet certain quality standards. Further on there are rules about transportation equipment and ways. In regional planning land usage should be allotted in a way that pollution in housing areas is avoided as much as possible.

B. Water

According to the environmental program of the federal government the minimum water quality everywhere should be Gewässergüteklasse II that is the second best out of four levels. But one cannot speak of an ambient standard as in the case of air pollution since the measures taken on the emission side are not derivated from this goal[1]. The main legal bases of the German environmental policy with respect to water are the fourth amendment of the Wasserhaushaltsgesetz in 1976, the Abwasserabgabengesetz which came into effect January 1st 1978 and

[1] A waste load equivalent to this goal is free of charge in the German Abwasserabgabengesetz so that it seems not to be pursued seriously.

the Waschmittelgesetz of 1975. The latter one regulates the contents of detergents.

According to § 7 a Wasserhaushaltsgesetz an authorization to discharge waste water is given if quantity and harmfulness are as small as possible by applying general recognized rules of technology (allgemein anerkannte Regeln der Technik). These rules are less demanding than the best available technology (Stand der Technik) in the case of air. But it seems not to be clear what is generally recognized since the law provides for a specifying decree. It is not out yet and the government and the lobby are working on it. Till now some normal standards (LAWA-Normalwerte) are used. They are based on averages and the administration can demand for more or less (Umweltgutachten 1978, Ziff. 1588).

For existing discharges not according to the rules the administration can demand correction. But faced with the economic consequences softer strategies are often used (Umweltgutachten 1978, Ziff. 1593 ff.). In the long run some more rigorous tools given in the Wasserhaushaltsgesetz as the Abwasserbeseitigungsplan (§ 18 a), the Reinhalteordnung (§ 27) and the Bewirtschaftungsplan (§ 36 b) will become relevant since the effluent charge act (Abwasserabgabengesetz) was crippled. So administrative planning will substitute the economically more efficient tool of effluent charges.

The aim of the Abwasserabgabengesetz is to improve water quality with least cost particularly by building large clearing plants to get economies of scale, by improving clearing techniques, by changing production processes to less waste discharging ones and by cutting down waste water intensive productions with the help of rising prices. A damaging unit is defined in the law and all dischargers as public authorities or private firms have to pay for the units beginning with 12 DM per unit from January 1st 1981 on and reaching a high of 40 DM from 1986 on. The units are defined as absolute loads but a certain load equivalent to the concentration of Gewässergüteklasse II is free of charge and if polluted water is taken in the corresponding damaging units can be deducted. In the originally proposed law 25 DM per unit were to charge in 1979 and 40 DM from 1980 on. These rates are a little bit higher than the estimated costs of efficient clearing plants to give an incentive. But they are not high enough to achieve the goals of the environmental program of 1971 (Deutscher Bundestag Drucksache 7/2272, p. 23). By the existing law the rates are practically delayed for six years and more important the rates are cut down to half for all dischargers fullfilling the requirement of § 7 a Wasserhaushaltsgesetz. Since these are conditions for the authorization of discharge the illegal discharging units only have to pay the full rate. Taking into account the inflation rate and the cut of the charge rate one is led to the conclusion that this effluent charge is not the effective instrument of environmental policy with respect to water. The real working tool is the emission standard. Looking at the political process of defining the exact standard which is underway at the time the existence of the charge may lower the pressure by the industry to set lower standards. In Fig. 2 the emission standard at *B* is lower than the application of the full rate of charge would imply at *H* but higher than that corresponding to the half. Lowering the emission standard to *A* would reduce costs for *ABFG* but enlarge the charges from *BCDE* to *ACDG*. The net incentive to reduce the standard is only *GEF*. Without the charge it would be the total of the purification cost. With the charge there is no incentive for

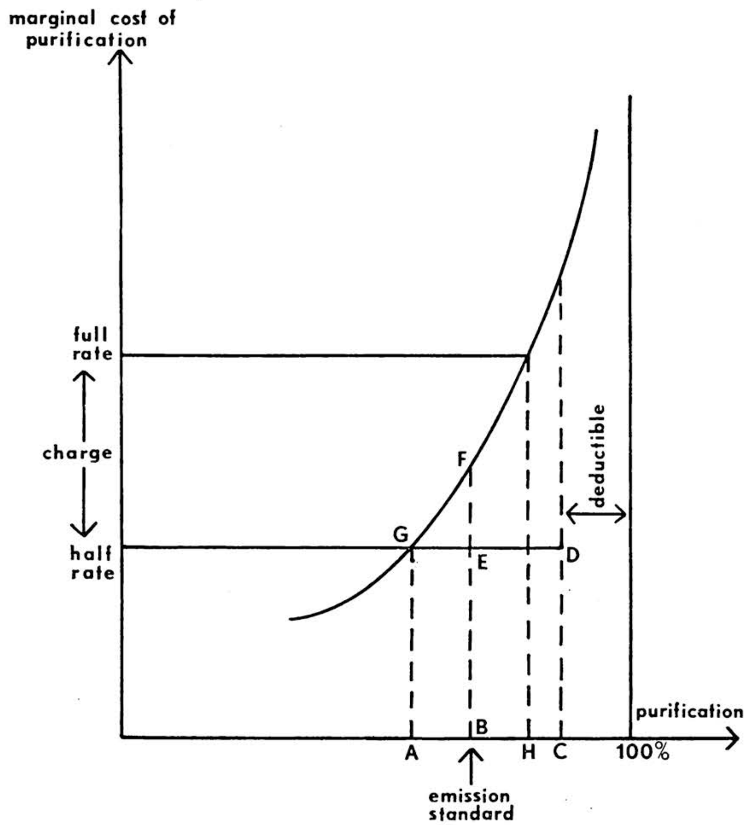


Fig. 2

a smaller standard than A. On the other end there may be serious opposition to higher standards than H because more firms cannot meet the standard and have to pay the full rate.

The political pressure against the originally proposed rates may be explained by the fact that some industries would have been seriously affected. For 1974 *Rincke* estimated the burden of the charge and the induced avoidance costs as given in Table 1.

Table 1

Waste water charge and induced avoidance cost as % of revenue 1974
(For a charge of 40 DM per damage unit)

Industry	%	Industry	%
pulp	26,6	cosmetics	0,3
yeast	2,25	breweries	0,22
leather	2,2	coal	0,2
paper	1,7	sugar	0,18
starch	1,7	meat	0,056
rayon	1,2	iron and steel	0,053
pharmaceuticals	1,0	margarine	0,03
dye-stuff	0,6	automobiles	0,027
laundries	0,34	machinery	0,020
textiles	0,33	federal railways	0,020
alcohol	0,3	electronics	0,017
fruit and vegetables	0,3		

Source: *Rincke* (1976), S. 116 - 117.

Since the charge revenue has to be used for water purification purposes the effective burden may even be lower. The exact determination of spending is left to the states and is not yet determined. For the most affected pulp industry the escape clause of the law may be engaged some day.

Besides the already mentioned fact that the charge rate has no effect on the degree of purification the law may be critized because it takes not into account the immission situation by regional differentiation. Since only the additional waste load is charged there is no incentive to avoid high regional concentration of pollution. In the whole one has the impression that the underlying philosophy of the law is not that of a tool of allocation but that the duty of dischargers is to use a certain technology and disobeying is to be punished (by the charge).

C. General Tools

One instrument of the German environmental policy which is laid down in the acts concerning air, water and waste is the "Betriebsbeauftragter". This is a person in charge of the environmental duties of the firm. It may be the same person for all three concerns. According to the laws these persons have to be given a room and other measures to fullfill their duties. They have the right to be heard by the management and to give advice concerning investment projects. They must not be an employee of the firm but will often be. For this case the laws contain protecting regulations. The instrument "Betriebsbeauftragter" is quite new. Similar arrangements are known only for the security of workers. By these laws the autonomy of the firms to organize themselves was limited. Experience will show whether the aim of fullfilling external and internal needs at the same time will be achieved.

A general instrument of perhaps greater relevance than the mentioned environmental laws may be the financial aid for investment in equipment protecting the environment. By this it may be explained that on the question whether they did invest in environment protecting equipment without being forced to by existing or expected injunctions 76 % of the firms answered in the affirmative as *Heigl* reported (*Heigl* 1975, p. 18 - 21). Concerning accelerated depreciation *Heigl* himself is critical about the magnitude of induced additional investments. But he did not take into account the cheap loans made available for investments protecting the environment. They are roughly of the same volume as the delayed tax payments (*Sprenger* 1975, p. 114) and may form the incentive for the 50 % of investment not supported by accelerated depreciation. A single firm may enjoy both incentives at the same time. One interesting result of *Heigl* with respect to market structure was that the bigger firms could apply accelerated depreciation to a higher percentage of the investment (50 % against 39 % in the average).

The incentive in the tax area consists of a depreciation of 50 % for mobile and 30 % for immobile goods in the first year besides straight-line depreciation. In the case of loans the incentives are lowered interest, long terms, amortization delay, grants and guarantees. Most of the aid is made available by programmes of ERP (European Recovery Program, special assets), KW (Kreditanstalt für Wiederaufbau) and the Länder. It should be mentioned that there is an information of the Commission of the European Community, dated November 6th 1974, concerning governmental subsidies for the protection of the environment. It is stated that those are not compatible with the polluter pays principle officially established by the Community. Under certain conditions subsidies are temporary allowed until the end of the year 1980.

IV. Environmental Policy and the Firm

To analyse the impact of environmental policy on industrial structure a model of the impact on the firm may be usefull. As was shown above the overwhelming part of the instruments of environmental policy is effective when the investment decision is made. Therefore the impact on the selection of a project shall be analysed. In general the reaction model of section II can be filled up with this. But here some more details with respect to industrial structure are of interest as plant size, location, capital intensity, technology and materials used.

An investment project may be planned for a typical yearly output X which requires a certain physical capacity depending on the typical degree of utilization. The firm has the choice between carious engine-degree of utilization. The firm has the choice between various engine-usage functions. They give the minimum factor quantity necessary for production of X. If there are substitution possibilities this will be expressed by different engineering processes: For simplicity three groups of factors are distinguished:

invested factors (capital) (9) $$r_K^j = r_K^j\,(X)$$

currently used factors (10) $$r_c^j = r_c^j\,(X)$$

waste disposed of (11) $$w_c^j = w_c^j\,(X)$$

In this context it is convenient to treat waste disposal like a factor. The price for it may be zero or that one to be payed to a waste treating unit or an effluent charge. In many cases the waste generated in the production process can be transformed into another less harmfull form of waste w_c^a or even into products with positive prices. This can be described by additional engineering processes a.

(12) $$r_K^a = r_K^a\,(w_c^j, \eta)$$

(13) $$r_c^a = r_c^a\,(w_c^j, \eta)$$

(14) $$w_c^a = w_c^a\,(w_c^j, \eta)$$

Factor usage and disposal of transformed waste depend on waste input and the degree of purification for certain kinds of waste.

(15) $$\eta = \frac{w_c^j - w_c^{jR}}{w_c^j}; \quad w_c^{jR} = w_c^j\,(1 - \eta)$$

w_c^{jR} is the left over waste in the original form.

As a criterion for the evaluation of investment projects the net present discounted value (PDV) shall be used.

$$PDV = \sum_t q^{-t} \cdot X_t \cdot p_{Xt} \tag{16}$$
$$- \sum_t q^{-t} \sum r_c^j \cdot p_r^j - \sum_t q^{-t} \sum w_c^j \cdot p_w^j$$
$$- \sum_t q^{-t} \sum r_c^a \cdot p_r^a - \sum_t q^{-t} \sum w_c^a \cdot p_w^a$$
$$- \sum r_K^j \cdot p_K^j - \sum r_K^a \cdot p_K^a$$
$$+ (s^j + z^j) \sum r_K^j \cdot p_K^j + (s^a + z^a) \sum r_K^a \cdot p_K^a$$
$$- \sum_t q^{-t} \cdot R_t$$

With discount factor $q = 1 + i$ and prices p the first row gives the discounted value of revenues, the second that of current outlays and the third that for additional waste treating processes where some prices may be negative if treated waste can be sold. The fourth row represents the initial capital outlays. Since as shown above financial operations are linked to these environmental projects they have to be regarded. In the fifth row the corresponding financial inflows are written down with the share s of capital outlay given as cheap loan and z the share given as grant. The effect of the grant is clearly a reduction of capital expenditure of the firm and therefore favours capital intensive projects. The same can even be shown for the loan if the interest rate $\hat{\imath}$ is lower than that one used for discounting. For redemption and interest payments R_t in the last row being calculated as constant annuities A the present discounted value is lower than the loan. With $\hat{q}$ the annuity is

$$A = \frac{\hat{q}^n (\hat{q} - 1)}{\hat{q}^n - 1} \cdot s \cdot \sum r_K \cdot p_K \tag{17}$$

and its present discounted value

$$PDV(A) = \frac{q^n - 1}{q^n (q - 1)} \cdot \frac{\hat{q}^n (\hat{q} - 1)}{\hat{q}^n - 1} \cdot s \cdot \sum r_K \cdot p_K \tag{18}$$
$$= \frac{(q^n - 1) \cdot (\hat{q} - 1)}{\left(q^n - \frac{q^n}{\hat{q}^n}\right) \cdot (q - 1)} \cdot s \cdot \sum r_K \cdot p_K$$

For $\hat{q} < q$ the coefficient is smaller than one with the effect that such a loan increases PVD like a grant with the volume

$$\left[1 - \frac{(q^n - 1)\cdot(\hat{q} - 1)}{\left(q^n - \dfrac{q^n}{\hat{q}^n}\right)\cdot(q - 1)}\right]\cdot s \cdot \sum r_K \cdot p_K \tag{19}$$

It can be shown that accelerated depreciation has a similar effect.

The selection of a project is subject to the restrictions and incentives of environmental policy. Prices and charges for waste disposal will favour processes generating less waste. Emissionstandards may exclude some processes or may permit them at a smaller scale only or they may call for additional waste treating processes. Thereby achievable present value is diminished and may even become negative so that the whole project has to be turned down. If the allowed emission depends on the region another location of the plant may help which probably will not have been the first choice of the firm. In the general case when observation of best available technology etc. is required this too constraints the choice set of production processes or calls for additional processes which reduces the achievable present value.

With respect to industrial structure an important characteristic of factor usage functions particularly applying to waste eliminating and waste treating equipment must be described. For the media to be purified as air and water there have to be vessels and pipes or channels somehow. Factor quantities to build these are proportional to the surface while the throughflow of the media is proportional to the volume or sectional area. As can be shown for simple containers as spheres, cubes or cylinders the surface is less than proportional to the volume, it increases with the power of $^2/_3$ or $^1/_2$ only[2]. This has the effect that big equipment uses less capital per treated unit than small equipment. Even currently used factors can be saved as in the case of heat where losses are proportional to the surface. So there are considerable economies of scale in waste treatment.

With respect to purification degree one can expect considerable diseconomies of scale. This stems from the fact that purification in one step is often limited to a certain degree η. To get more purification further steps must be added. Since the whole volume has to be treated the additional steps require roughly the same factor quantities as the first one. But the purification degree will be η only in the best cases since the more difficult to catch waste remained. Even assuming an equal degree of purification per step it can be shown that there are decreasing marginal returns to additional steps. The proportion of left

[2] Sphere: Surface = 4,84 · Volume$^{2/3}$; Cube: Surface = 6 · Volume$^{2/3}$; Cylinder with open end: Surface = 3,54 · Length · Sectional area$^{1/2}$. Empirical cost studies of biological purification plants show quite similar exponents, for construction costs 0,67, for total yearly costs 0,68 (*Schmidt* 1964).

over waste to the original one is $1 - \eta$ per step. A series of n steps then shows a proportion of $(1 - \eta)^n$ since the outflow of one step is the inflow of the next one. For the total purification degree we have $1 - \eta_{tot} = (1 - \eta)^n$ or

$$\eta_{tot} = 1 - (1 - \eta)^n \ . \tag{20}$$

Especially for small η's the total purification degree achieves sufficient values only with a considerable number of steps, e. g. for $\eta = 0{,}5$, $\eta_{tot} = 0{,}5; 0{,}75; 0{,}87; 0{,}94; 0{,}97$. If there were an absolute emission limit, e. g. a certain amount of tons per day then bigger production plants would have to achieve a higher purification degree than the smaller ones. This can be seen by an interpretation of (15) for a limited amount of left over waste and bigger plants generating higher input waste. They would run therefore into these diseconomies and mostly other locations with higher limits would have to be found. But for most cases the emission standards are formulated as a prescription of a certain technology involving one or two steps which means a certain purification degree and therefore "excessive" costs are avoided. The advantage of big plants is maintained also (see Appendix 2).

V. Consequences for Market Structure

For analyzing structural effects of environmental policy there is only a weak data base till now. An act concerning environmental statistics came into effect in August 1974, but only few very special data have been published yet. The available data come from the Batelle Institute (1975) for 7 industry groups and from the Ifo-Institute (*Sprenger* 1975 and 1977, pp. 4 - 18) for 18 industries. The most reliable and detailed data are those of investment figures since they have to be known for the financial aid programmes. Current costs are estimated being 1,5 to 1,7 times of investment figures and together with investments the environmental burden accounts for 0,8 % of sales of the whole industry for 1971 - 1975 (*Sprenger* 1977, p. 6). The council of experts for the environment estimates the burden to 1,5 % of GNP for 1970 - 1974 (Umweltgutachten 1978, Ziff. 1345). One should keep in mind that estimated monetary costs do not correctly reflect the opportunity costs. If environmental policy induces a change in engineering processes this may mean a complete change of the factor input vector, the waste output vector and even the product output vector. A correct statistical report of the imputed environmental costs seems a difficult if not hopeless task. In addition these technology switches make a study of the impact of environmental policy on sectoral structure using input-output-models as *Fazio* and *Lo Cascio* (1972, pp. 143 - 179) did very doubtfull in value. It seems necessary to do industry studies first[3].

About 51 % of the investments of the german industry for environmental purposes have been done for water, 40 % for air, 4 % for solid waste and 5 % for noise. (Umweltgutachten 1978, Ziff. 1335). There are significant economies of scale in water purification. As can be seen from Appendix 2 for a purification degree of 0.85 a 200 times bigger plant gives a 4 times higher waste elimination per DM expenditure which means average costs are one fourth. Similarly big waste burning units show cost diminution of one half to one fourth (Umweltgutachten Ziff. 645, Abb. 7). Often they have to be used to burn the sludge extracted from waste water. Since there are such enormous economies of scale small firms try to avoid investment in waste treating equipment and engage private or public firms. This is possible in the cases of water (63 % of the fees) and solid waste, but not in those of air and noise. As can be seen from Table 2 smaller plants pay more fees per employee and per DM sales.

Table 2

Size, Investment and Compensations for Environmental Services[a)]

plants with employees	investment for environmental purposes	fees, compensations 1971 - 1973	
	% of total investment 1971 - 1973	DM per employee	% of sales
50 - 199	3,1	102	1,4
200 - 999	4,2	88	1,2
1 000 -	2,6	59	0,8
total	2,9	67	0,9

a) Without chemical and iron industries. Umweltgutachten 1978, Ziff. 1340 - 1342.

But they have also to spend a higher percentage of their investment for environmental purpose than the biggest ones. Plants of the smallest size invested less than medium size plants. According to other figures reported by the council of experts on the environment (Umweltgutachten 1978, Ziff. 1340)[4] even the medium size plants showed lower percen-

[3] *Leone* (ed.) (1976).

[4] These figures are based on the Batelle study which did not contain the smallest size group. Similar but more detailed figures are given by *Hansmeyer* (1976), p. 236, 237.

tages of investment for environmental purposes than the biggest ones. But all industries are lumped together here and therefore these figures may reflect the fact that the more burdened industries are those with higher concentration and bigger plants as shown in the next paragraph.

The economies of scale lead to the hypothesis that environmental policy favours concentration. This was tested for 15 industries with data given in Appendix 1. The indicators for the affectedness by environmental policy are the investment for environmental purposes as percent of total investment (Inv) and as per thousand of sales (Sal) in the period 1971 - 1975. Concentration is measured by 3 and 10 firm concentration ratios and by the number of firms in 1975. The highest F-values were found for linear equations. All concentration measures showed the expected signs. The 3 and 10 firm concentration ratios regressed on investment percentage are significant on the 1 % level, the others on the 5 % level.

(21) $CR_3 = 5{,}24 + 2{,}42$ Inv; $R^2 = 0{,}57$; $F = 15{,}15$

(22) $CR_{10} = 11{,}96 + 4{,}23$ Inv; $R^2 = 0{,}61$; $F = 12{,}58$

(23) $CR_3 = 7{,}63 + 3{,}36$ Sal; $R^2 = 0{,}42$; $F = 7{,}80$

(24) $CR_{10} = 15{,}75 + 6{,}01$ Sal; $R^2 = 0{,}45$; $F = 7{,}44$

(25) Numb $= 2635 - 187{,}3$ Inv; $R^2 = 0{,}33$; $F = 8{,}50$

(26) Numb $= 2609 - 307{,}3$ Sal; $R^2 = 0{,}34$; $F = 8{,}15$

So industries with higher environmental burden showed higher concentration. But did environmental policy cause concentration? All regressions for change variables 1968 to 1975 were insignificant but had the expected sign of regression coefficients with the exception of (32).

(27) Change $CR_3 = 96{,}39 + 0{,}57$ Inv; $R^2 = 0{,}01$; $F = 0{,}02$

(28) Change $CR_{10} = 98{,}89 + 0{,}51$ Inv; $R^2 = 0{,}02$; $F = 0{,}02$

(29) Change $CR_3 = 95{,}31 + 1{,}25$ Sal; $R^2 = 0{,}025$; $F = 0{,}035$

(30) Change $CR_{10} = 97{,}63 + 1{,}21$ Sal; $R^2 = 0{,}05$; $F = 0{,}03$

(31) Change Numb $= 97{,}52 - 0{,}16$ Inv; $R^2 = 0{,}002$; $F = 0{,}002$

(32) Change Numb $= 95{,}52 + 0{,}33$ Sal; $R^2 = 0{,}003$; $F = 0{,}003$

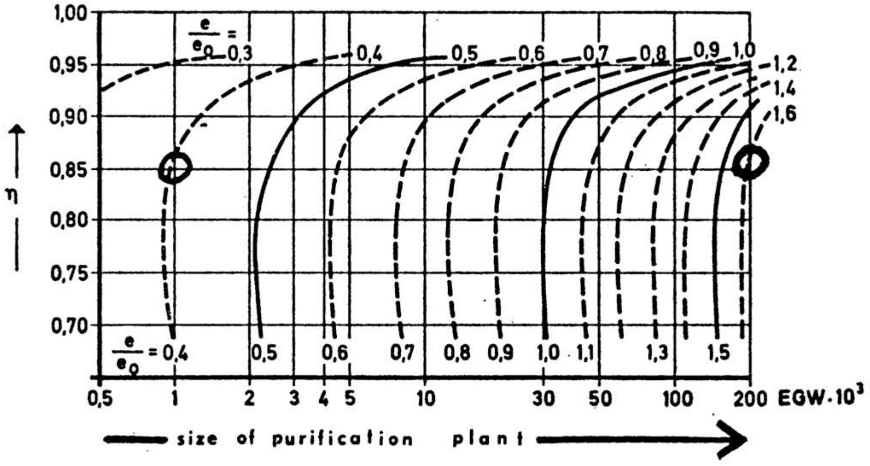
So the conclusion to be drawn is that environmental policy encumbers concentrated industries more but does not significantly induce concentration. The reason may be that the more environmental burdened industries show up already similar economies of scale as those for waste treating equipment.

Appendix 1

Industry	1975 Sales of the				Number of firms		Investment for environmental purposes 1971 - 75	
	biggest 3 %	biggest 10 %	biggest 3 1968 = 100	biggest 10 1968 = 100	1975	1975 1968 = 100	% of total investment	‰ of sales
iron and steel	39,5	75,1	125,4	116,4	87	100,1	9,3	7,1
iron and steel foundries	18,4	37,6	112,2	126,2	609	94,1	8,0	6,4
non ferrous metal	24,9	50,5	74,3	85,4	178	107,9	8,6	5,8
petroleum processing	50,4	87,2	102,9	105,2	74	92,5	17,3	6,8
chemical industry	27,0	46,6	99,3	103,3	1638	93,0	11,1	8,3
saw mills	8,2	20,5	134,4	109,6	1085	86,7	4,9	3,1
machine building	9,1	17,8	89,2	100,6	4636	104,3	1,3	0,6
electrical engineering	32,1	48,3	99,4	107,1	2283	111,9	1,9	0,9
steel reduction	8,0	17,8	79,2	87,7	1755	105,6	3,4	1,8
metal processing	6,5	12,3	125,0	107,9	3089	92,1	2,2	1,0
fine ceramic	24,9	45,9	104,0	101,8	235	86,4	3,4	2,1
wood processing	3,4	9,6	n. a.	106,7	2437	88,0	2,7	1,1
plastic processing	5,8	14,0	68,6	68,6	1919	139,0	3,6	2,5
leather production	18,6	40,6	113,9	115,0	114	68,3	3,1	1,1
food	5,7	11,8	67,9	83,7	3599	79,2	3,5	1,5

Data sources:
Concentration: Monopolkommission (1976), p. 573, 640, 620 and (1978), pp. 449 - 452.
Investment for environmental purposes 1971 - 1975: *Sprenger* (1977), p. 7. Three industries of this sample were omitted. For the pulp and paper industry there were no corresponding concentration data. The automobile industry is extremely concentrated surely not for environmental reasons and the industry of non-metallic minerals is strongly affected by environmental protection but not concentrated for reasons of nature and transport costs.

Appendix 2



Source: *Rincke* (1976), p. 104.

Fig. 3: Iso-return-lines per cost unit for purification plants

In this diagram the reciprocal of the return index is an index of average costs per eliminated waste unit. So e. g. for a purification degree of $\eta = .85$ a rise of plant size from 1 to 200 brings about an increase of the index from 0.4 to 1.6 which means four times lower average costs. If on the other hand the purification degree shall be increased e. g. to .95 then for a size of 200 the index goes down to 1.0 which means 1.6 times higher cost per eliminated waste unit.

Summary

On the background of a basic model of environmental policy the main goals and remedies of German environmental policy for air, noise and water are analyzed. The main instrument is the authorization of equipment. It depends in some cases on fulfillment of standards for immission and emission and mostly on the application of appropriate technologies. In addition subsidies for investments for environmental purposes have been used. The hypothesis that environmental policy favours concentration is tested and rejected since the change of concentration is not significantly correlated with environmental policy burden as it is the case with the level of concentration.

Zusammenfassung

Auf dem Hintergrund eines Basismodells der Umweltpolitik werden die hauptsächlichen Ziele und Mittel der deutschen Umweltpolitik für die Bereiche Luft, Lärm und Wasser analysiert. Das wichtigste Instrument ist die Genehmigung von Anlagen. Sie hängt in einigen Fällen von der Erfüllung

von Immissions- und Emissionsstandards und in den meisten Fällen von der Anwendung angemessener Technologien ab. Zusätzlich sind Subventionen für Umweltschutzinvestitionen angewandt worden. Die Hypothese, daß die Umweltschutzpolitik die Konzentration begünstigt, wird getestet und zurückgewiesen, weil die Konzentrationsänderung nicht signifikant mit der Umweltschutzlast korreliert, wie das beim Konzentrationsstand der Fall ist.

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