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# Methodological Aspects of Environmental Labour Market Analysis

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**Abstract**

*High and persistent unemployment rates and increasing awareness of environmental degradation in many industrial countries have promoted the interest in the labour market effects of environmental policy. Environmental labour market analysis is fraught with many difficulties, however. Being unaware of these problems may result in misunderstandings and mislead policy makers.*

*In environmental labour market analysis two kinds of questions have to be distinguished: firstly, accounting for the number of persons working directly or indirectly for environmental protection activities and secondly, identifying the net effect of environmental policy on the labour market balance. Answering the first question is not conceptionally contentious. However, elaborating quantitative estimates poses a variety of problems of delimitation and data collection which are discussed in some detail in section 2. This section also presents the results of studies assessing environmental employment in Germany in various dimensions. Section 3 deals with problems arising when one attempts to answer the question of how many additional jobs are created through environmental policies. This requires an assessment of secondary economic effects of environmental policy the size and even the direction of which depend on a variety of framework conditions in a complex way. Quantitative estimates can only be based on model simulations; thus the features of the models applied become crucial for the results. Some rules for making such estimates are discussed. The most important mechanisms to be taken into account are presented. Some examples of empirical studies for Germany are presented in order to illustrate the argument. The most important conclusion we draw is that the delimitations, methods and assumptions underlying any estimates of the labour market effects of environmental policy have to be clearly stated.*

# 1 Introduction

In the majority of industrial countries high and persistent unemployment poses the most important challenge for economic policy. At the same time the awareness of environmental degradation has increased. Searching for strategies which are able to cope with both the unemployment and the environmental problem has increased the interest in the labour market effects of environmental policy. Environmental labour market analysis is fraught with many difficulties, however. Being unaware of these problems may result in misunderstandings and mislead policy makers. To avoid confusion it is first of all important to make a clear distinction between two kinds of questions which may be analyzed in environmental labour market analysis:

I. How many persons do have a job in the economy as a whole due to environmental protection activities?
II. What is the net impact on employment if a certain strategy of environmental policy is followed in the future?

The first question adresses the problem of counting the number of persons working directly or indirectly for environmental protection activities. Answering this question mainly poses statistical difficulties, namely problems of delimitation and data availability. Quantitative estimates may therefore diverge widely. Making explicit the underlying delimitations and data helps to avoid misunderstanding and confusion.

The second question is methodologically more challenging. It adresses the question of the net effects of environmental policies on the labour market. Giving an answer to this question requires to take into account secondary economic effects of environmental policy as compæhensively as possible, e.g. to account for possible job losses due to cost and relocation effects. The only way to assess quantitatively such effects is through model simulations. As any such model is unlikely to capture all relevant effects, a valid and complete answer is unlikely. Much of the controversy in this field is due to the fact that different models focus on different mechanisms. Using a variety of models and approaches, being each time careful in defining the captured effects and mechanisms, may help to give a realistic picture of the magnitude of

the net effect of environmental policy on employment or may at least help to define conditions for a relatively favourable net effect.

## 2 Accounting for Environmental Jobs

Counting the number of persons being employed through environmental protection activities seems to be quite straightforward. After all, answering this question does not require any reference to hypothetical situations. In practice, however, widely differing figures are presented.

### 2.1 Problems of Delimitation and Data Collection

Two kinds of problems are responsible for the apparent confusion. First, problems of delimitation arise, such as: Which activities should be regarded as environmental protection? Should non-market activities such as the operation of a filter be included? Secondly, once an appropriate delimitation has been established, there are difficulties of data collection: many of the jobs due to environmental protection activities cannot be counted directly but have to be estimated relying on assumptions which are sometimes crucial for the results obtained.

*Problems of Delimitation*

Environmental protection may be defined as actions and activities which have as their prime objective the prevention, reduction and elimination of degradations of the environment (Eurostat 1994). This definition excludes activities which, while beneficial for the environment, primarily satisfy other needs. Such a general delimitation leaves room for arbitrariness. For example, recycling activities which pay for themselves should not be included according to this definition. Likewise many energy saving as well as transport related activities do not qualify as environmental protection by this definition. To avoid arbitrariness reference can be made to a classification of environmental protection activities, for example that agreed upon at the European level (Eurostat 1994). This classification breaks down activities the purpose of which is environmental protection by their domain (air pollution, surface water pollution, etc.) and their type (pollution prevention, pollution reduction, etc.). In any case, a precise de-

limitation of what is regarded as environmental protection should be given along with any estimate of the number of environmental jobs.

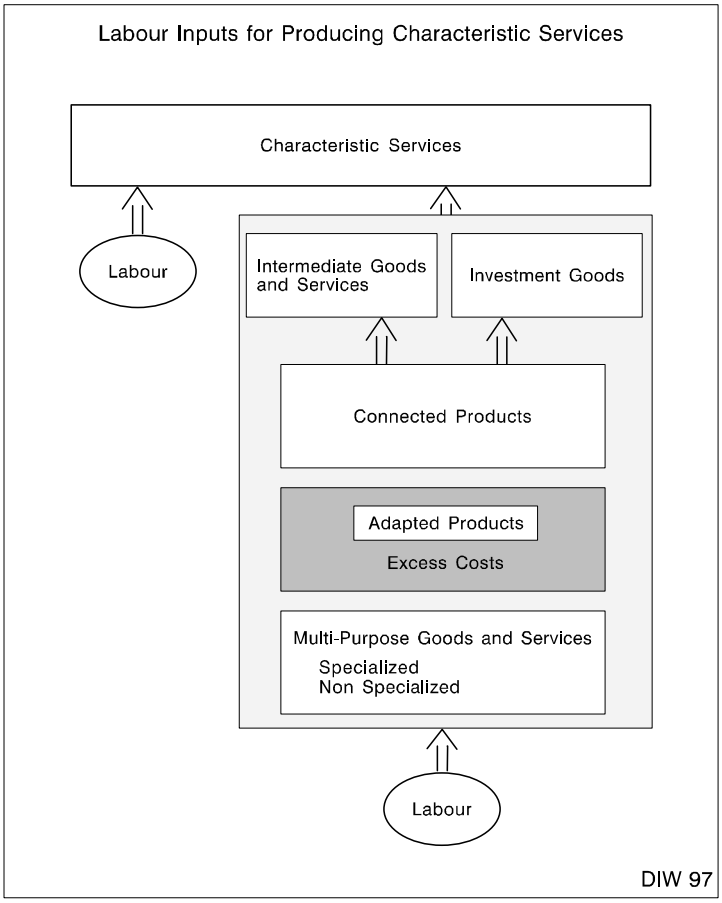
Environmental protection activities, also termed characteristic activities, yield characteristic services (Figure 1). Characteristic services are produced by combining labour, capital goods and intermediate inputs. Labour inputs for producing characteristic services are straightforwardly counted as environmental employment. Capital goods and intermediate inputs may have no use except environmental protection; they are then referred to as *connected products.* In this case it seems obvious to count the amount of labour used for their production as environmental employment. If such products have a primary use other than environmental protection but are less pollutant during use and when scrapped in comparison to equivalent „normal" products (so called *adapted products*), it could be argued that they should be regarded as environmental protection. The employment effects of their production should then be accounted for as environmental jobs but only to the extent to which they are more expensive than equivalent „normal" products.

Most of the capital and intermediate goods used for producing characteristic services are neither connected nor adapted but might serve multiple other purposes as well. Still, the jobs which their production provides would not exist if there were no environmental protection activities. The same argument can be made for including the amount of labour embedded in all previous stages of production of all goods and services used for producing characteristic services when counting the number of environmental jobs. Generally the labour used in previous stages of production is characterized as indirect employment effects of environmental protection; in practice only intermediate inputs are taken into account while capital inputs at previous stages are neglected.

For multi-purpose products used for producing characteristic services a distinction is sometimes made between *specialized products* which are designed to be used for characteristic activities (but not in a way which excludes their use for other purposes) such as waste water pumps and *non-specialized products* such as concrete. The term eco-activities is used to designate all activities which produce characteristic services, connected and adapted products, as well as specialized products (Eurostat 1994). The *environmental industry* is narrowly defined as the group of producers of connected, adapted and specialized equipment. In a broader sense

it includes suppliers of market-traded environmental services such as waste and waste water management, consulting and maintenance, etc.

**Figure 1**




*Problems of Data Collection*

Data on the number of environmental jobs are difficult to collect since environmental protection is a cross section activity cutting across standard classifications. Basically they can be obtained from analyzing either the supply or the demand of the relevant goods and services (OECD 1996). In practice, combinations of the two approaches prevail.

*Supply Side Approach*

The supply side approach starts from a list of goods and services relevant for environmental protection. Usually labour employed in the production of characteristic services is easily accounted for if these services are sold on markets. An assessment may prove to be more difficult if they are provided through non-market procedures or if they are *ancillary activities*, i.e. executed by producers on their own and for their own use. For adapted products procedures have to be developed to isolate the additional costs of such products.

It is obvious that any attempt to assess labour inputs for the production of non-specialized goods based on production statistics, i.e. from the supply side, requires information on the final destination of the products in question which is usually difficult to obtain. This implies that a supply side approach will not capture most of the indirect employment effects of environmental protection. For specialized goods the problem is less severe, at least it is conceivable to establish lists of such goods. However, in order to be precise, a term like „goods relevant for environmental protection“ should be used if production statistics have been exploited without an inquiry into the final destination of the products.

Statistical problems of using a supply side approach to accounting for the number of environmental jobs also arise from the fact that the production of environmental services often constitutes only a secondary activity of an establishment, or, if it is a principal activity, is combined with secondary activities in the same establishment. Unless available data allow a clear separation, the number of environmental jobs may be underestimated in the first case while it is likely to be overstated in the second case.

Still another serious problem of the supply side approach is that of a danger of double counting. If filter cloths and complete fabric filters are both included in a list of environmental goods the same filter cloths may be counted twice.

*Demand Side Approach*

The demand side approach starts from data about expenditure on pollution abatement and control, including outlays for labour, investment, and intermediate inputs (OECD 1996). In this way ancillary services may be assessed, the problem of multi-purpose goods can be circumvented, the secondary activities problem be resolved and double counting be avoided. The

demand side approach also allows for an estimate of employment generated indirectly through environmental protection by applying input-output techniques. The interpretation of the results is restricted through a variety of assumptions implicit in the input-output methodology, however.

The demand side approach does not yield data on employment immediately, however. Expenditure has to be transformed into production which in turn has to be linked to employment. The first step involves calculations of exports and imports which may pose particular difficulties in case of regional analyses. The second step requires information on labour productivity which is at best available in a sectoral classification; thus implying the need to disaggregate production by the sectoral dimension. Even then, average productivity for sectors may be a poor approximation for that with which eco-activities are performed.

The strengths and weaknesses of the two approaches to data collection outlined above suggest their integration within an accounting framework (Pasurka, Steurer 1995). Consistency can be ensured and cross-checking be facilitated by applying input-output techniques. This integrated approach seems particularly suitable to assess employment effects of cleaner technologies and to deal with environmental protection as a secondary activity. A deeper level of detail may be achieved if this approach is supplemented by engineering and case study data, but only at the expense of introducing additional hypotheses.

## 2.1 Employment Through Environmental Protection in Germany in 1994

If one is interested in the number of jobs which exist in the economy because of a certain level and structure of environmental activities, a demand oriented approach is usually applied. It starts from an estimation of expenditures for environmental protection activities. Expenditures considered include

- investment expenditure,
- current expenditure, comprising
    - expenditure for intermediate goods and services,
    - expenditure for personnel.

For a matter of convenience the persons directly involved in environmental activities are counted per head instead of accounting for their labour costs. Using an input-output based model analysis (termed as imputation analysis in the input-output literature) expenditures for investment and intermediate goods are in a first step transformed into induced gross production. In a second step the employment requirements to produce this gross production are calculated using sectoral labour coefficients.

This approach yields as a result the economy-wide gross effect of environmental protection activities on employment. It allows to distinguish between various components of this gross effect, e.g.

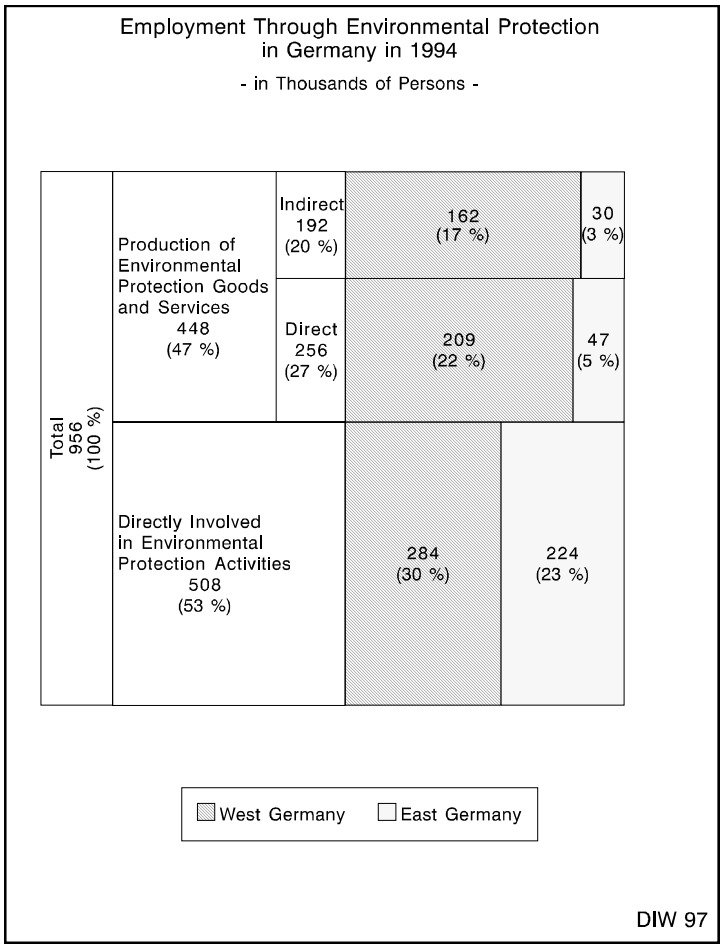
- the number of persons directly involved at their working place in environmental protection activities,
- the number of jobs directly induced by the demand for environmental protection goods and services and the number of jobs induced in the supporting industries (indirect employment).

It also provides a sectoral breakdown of these components of environmental protection.

Using this approach a recent study for Germany (DIW, Ifo, IWH, RWI 1996), to which the remarks in the previous chapter concerning problems of classification and delimitation apply, estimated the jobs created through environmental protection in the year 1994. According to this study the gross effect of environmental protection on employment amounts to 950 000 persons (Figure 2). This represents 2,7% of the employed labour force in Germany. In East Germany this relation is twice as high (4,7%), due to the clean-up activities underway in this region.

More than half of these persons are involved in environmental protection directly at their working place. More than 40% of this type of environmental protection jobs are in the government sector at the federal, Länder and community level. Another 20% of these jobs are in the waste management and recycling sector. The demand for environmental protection goods and services induces 450 000 jobs. Roughly 60% of these jobs are located in companies, which produce goods directly used in environmental protection, the other 40% are created in companies supporting this production through the delivery of intermediate goods. Sectors,

**Figure 2**




which profit most from the demand for environmental protection goods and services are construction (80 000 jobs) and machinery and equipment (60 000 jobs).

## 2.2 Environmental Employment by Regions and Occupations

Accounting for the number of environmental jobs at the regional level poses particular problems. First it requires to specify the demand for environmental goods and services at the regional level. A critical point of this method is to assess which fraction of the demand identified at the regional level becomes effective in or outside the region. It is equally difficult to estimate the demand from other regions (including foreign countries), which induces production in the region under investigation.

As regional input-output tables are rarely available national tables are used for the calculation. This does not only reduce the reliability of results but in addition it requires to estimate the

parts of the indirect production being produced in or outside the region and which are produced outside. Usually no data are available for these so called „local content“ coefficients, thus they can only be roughly estimated, e.g. on the basis of an assessment of the competitiveness and specialization of the local industry.

In a study for the city of Berlin this approach was applied (Blazejczak, Edler, Gornig 1995). The study estimated that from a demand for environmental protection goods of 2,7 bill. DM in the region in 1993, 52% becomes effective in the region itself, while 48% (1,3 bill. DM) flow into other regions outside Berlin. At the same time there was an inflow of demand of 0,6 bill. DM. In total 50 000 persons in Berlin owe their job to environmental protection, which represents about 3% of the labour force.

Statements about the number of jobs generated by environmental protection activities must not be mistaken for an information about the chances to find a job which allows the full time application of specific qualifications in ecology or related fields. A calculation for Germany (Gornig 1993) reveals that of all direct and indirect employment effects of environmental protection activities only 40% relate to jobs which deal with environmental affairs exclusively. In most of these cases, however, other qualifications such as medical or typing skills are more important than those in ecology. Only 7% of the (full-time equivalent) total employment effects of environmental protection are jobs where specific environmental qualifications dominate.

## 2.3 Jobs in the Environmental Industry

The environmental industry has been defined above as the group of producers of connected, adapted and specialised equipment for environmental protection. This industry competes on international and interregional markets with a presumably over-average growth potential and is therefore of particular concern to policy makers. As the environmental industry is not a separate item in common industrial classifications it can be investigated through special surveys only. This requires to identify the companies belonging to this sector. This can be done by scanning production statistics files for companies reporting the production of certain products identified as relevant for environmental production. A different procedure is to identify

companies which demonstrate activities in environmental markets e.g. by advertising or participating in exhibitions. Both methods may be combined to determine the intersection of both groups of enterprises.

The ‘size’ of the environmental industry can then be assessed by evaluating production statistics or by asking the enterprises identified, usually through a postal survey, to characterise that part of their business oriented on environmental protection and to provide information on these activities, e.g. on turnover and employment. As with any survey, issues of statistical sampling may arise. This concerns e.g. the problem of the representativity of the sample in relation to the population and the problem of finding appropriate weights to extrapolate the sample results. The reliability of results depends on the adequate handling of these problems. The method described above has been characterised as supply side approach in section 2.1. It has been pointed out that this approach may be impaired by several problems, in particular those of double-counting and handling of secondary activities.

A recent study (IWH, RWI 1994) concludes that in 1993 the environmental industry in Germany provided 170 000 jobs of which 150 000 are located in West Germany and 20 000 are in East Germany. Roughly 50% of the jobs can be attributed to the production of industrial commodities (first of all machinery and equipment), 25% belong to the construction industry and about 25% of the jobs either originate from the supply of services directly related to the production of commodities (like engineering services) or cannot be attributed to any of these categories. This study was based on a postal survey of some 5000 firms which were selected from a catalogue of suppliers of commodities for environmental protection. It may be interesting to note that only half of these firms (2535 enterprises) were finally classified as belonging to the environmental industry; some 17% of these enterprises responded to the questionnaire.

The German Federal Statistical Office identified some 1300 enterprises as belonging to the environmental industry in 1992 based on production statistics of the manufacturing sector (therefore excluding construction and services) combined with some proof of activity in the field of environmental protection. This compares to a figure of some 1800 enterprises identified as producers of commodities for environmental protection in the above mentioned survey.

# 3 Analysis of the Employment Effects of Environmental Policy

The question of how many additional jobs are created through environmental programs or instruments is a much more controversial one. To give an answer to this question requires to account for secondary economic effects of environmental policy as comprehensively as possible. In particular, possible job losses as a consequence of environmental policy have to be taken into consideration. As many secondary effects take some time to become fully effective, long term effects and short term effects may differ considerably.

Truly empirical studies of the net employment effects of environmental policy are inconceivable. The only way to assess such effects is through model simulations. Any such model is unlikely to capture all effects relevant for the consequences of environmental policy on employment. The fact that different models focus on different mechanisms is responsible for much of the controversy in this field.

## 3.1 Mechanisms Impacting the Net Employment Effects of Environmental Policy

Early attempts to estimate net employment effects of environmental programs focused on job losses in the energy sector setting off part of the jobs created through investments in energy efficiency (Garnreiter et al. 1983). Meanwhile a great number of additional mechanisms have been analyzed (Figure 3).

As a rule it can be expected that investigations into the employment effects of environmental policy are the more reliable the more of the mechanisms they capture.

However, models designed to capture all of the mechanisms relevant for an assessment of net employment effects tend to become unmanageable. Linking various models each of which focuses on particular aspects may help to overcome this problem. Model-linking poses serious problems of its own, however. Hard-linking requires a careful design of interfaces and may end up with problems of manageability. Soft-linking, i.e. using the results of one model as inputs into another model in an informal way, leaves room for some arbitrariness.

**Figure 3**

**Mechanisms Influencing the Net Employment Effects of Environmental Protection**

| Mechanism | Description |
|---|---|
| **Offset Effects** | Environmental policy may reduce the need for repairing or compensating damages |
| **Multiplier-Accelerator Effects** | Additional expenditure on environmental protection generates additional income and requires additional investment |
| **Crowding Out Effects** | Environmental investment may compete with other investment for financial and other resources |
| **Cost and Price Effects** | Environmental protection increases private costs of production which may result in lower production |
| **Relocation Effects** | Economic activities may be relocated to locations with less strict requirements |
| **Structural Effects** | Shifts of final and intermediate demand towards goods which are produced with a different amount of labour may affect employment even if total production remains unchanged |
| **Factor Demand Effects** | Changes in the relative prices of production factors may lead to changes of the labour intensity of production processes |
| **Innovation Effects** | Environmental policy may trigger innovation which increases competitiveness |
| **Resource Effects** | Environmental policy improves the quality of natural resources thus improving the performance of businesses relying in such resources |

A methodological issue of importance for estimates of the net employment effects of environmental programs is the distinction between their primary impacts and their secondary effects. Economic models usually do not represent the link between legal or administrative arrangements and economic variables such as investment or other expenditure. Therefore the primary impacts of such arrangements have to be established in terms of the model which

consequently evaluates the secondary effects. Depending on which primary effects are identified and which mechanisms are represented in the particular model applied the resulting net employment effects may differ widely. Care has to be taken to avoid both a „double counting“ as well as an omission of important effects.

Model outcomes on the net employment effects of environmental programs depend to a large extent on assumptions - often implicit in the model's structure - on a variety of framework conditions such as the behavior of the central bank or foreign competitors. These have to be carefully documented or, preferably, be tested with respect to their importance through sensitivity analysis.

Quite frequently an exploitation of technical information at an engineering level is required in order to comprehensively assess the employment effects of particular environmental policies. Difficulties arise as such micro information is not readily suited for being fed into macro models. Soft linking of models with different focuses may help to overcome this problem.

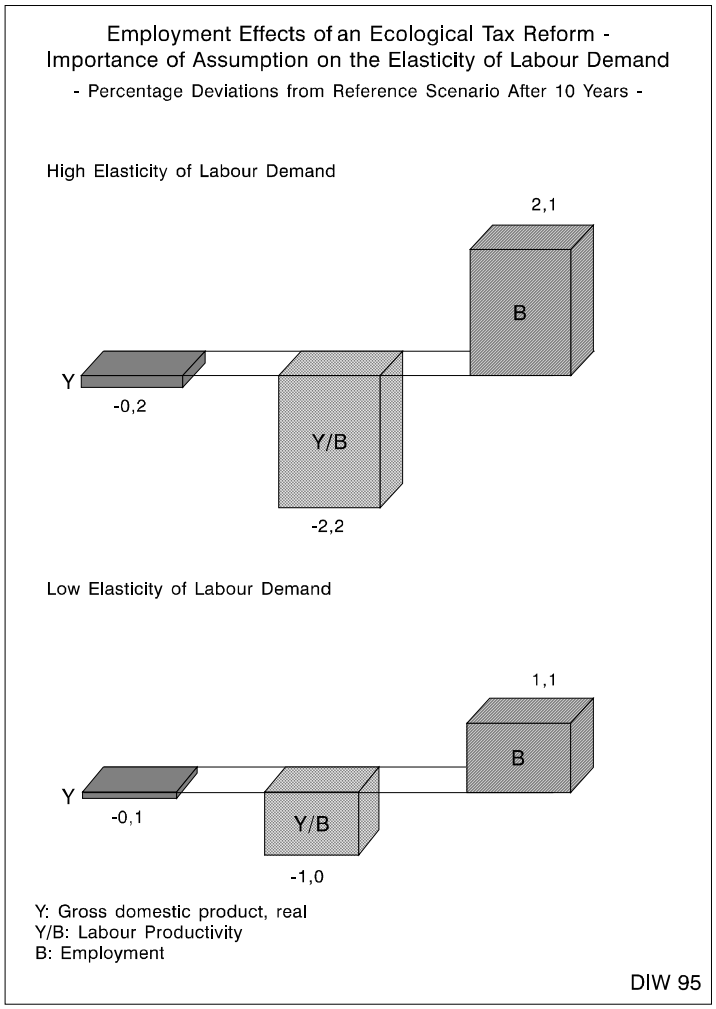
### 3.2 Employment Effects of an Ecological Tax Reform

The debate about the employment effects of an ecological tax reform provides an excellent example of the argument made above: depending on the assumptions made, and, in particular, on the mechanisms taken into account, the conclusions may differ widely and even with respect to the direction of the expected employment effects (see also Pfaffenberger 1995). Thus, one study for Germany (DIW 1995) concludes that an energy tax while reducing $CO_2$-emissions by 20% between 1990 and 2010 would result in additional employment of half a million persons 10 years after its introduction. A comparable study (Hillebrand et al. 1996) investigating an energy tax which would reduce primary energy consumption by some 20% between 1996 and 2010 concludes that by the end of this period more than 400 thousand jobs would be lost in the energy supply and basic materials sectors. While there are many possible mechanisms the inclusion or omission of which may explain such divergence, we will highlight the general argument by way of a few instructive examples.

Of central importance for the conclusions on the employment effects of an ecological tax reform are the assumptions made about the recycling of the revenues. This insight stresses the

necessity of an analysis within a complete framework of national accounts. According to one argument the revenues raised should be used to lower wage costs, thus shifting the price of labour relative to that of other factors of production into a direction favorable for additional employment. The employment effect depends of course on the elasticity with which factor demand reacts on prices. Figure 4 demonstrates the importance of this relation, using the example of the DIW-study mentioned above. In a first scenario labour productivity is reduced by more than two percent relative to the baseline through a shift of relative prices as a consequence of an ecological tax reform. As the tax reforms leaves production basically unaltered in the model, a corresponding increase in employment results. In an alternative scenario the (econometrically estimated) elasticity of labour demand is reduced by half. This does not significantly affect production, consequently the employment effect is only half of its previous value.

**Figure 4**

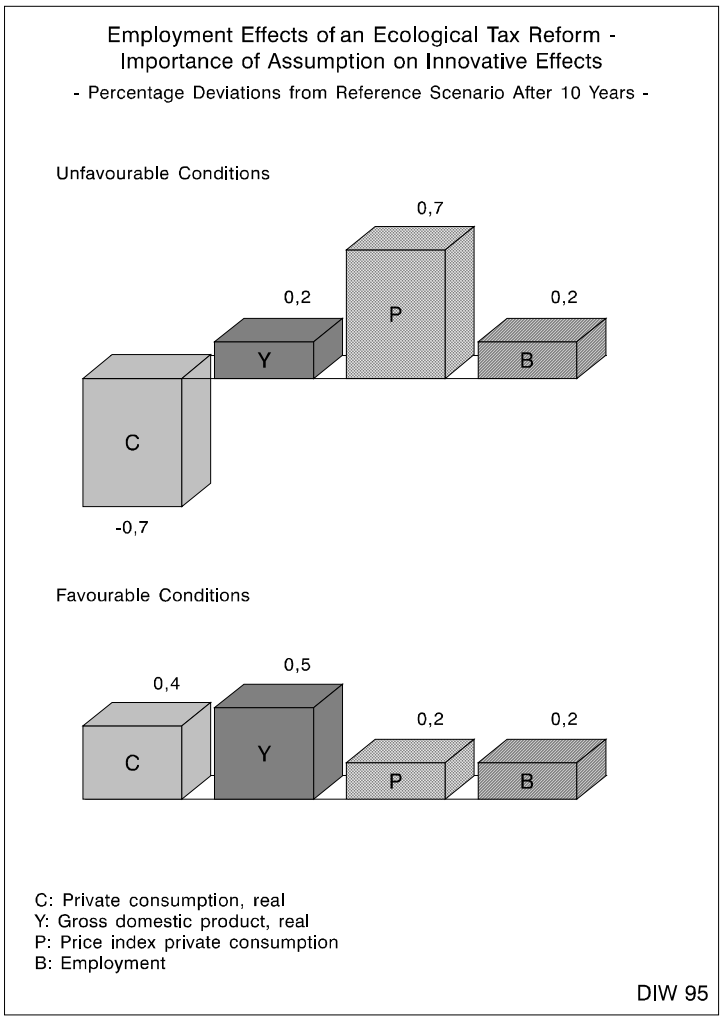


Assumptions on the wage-price mechanism are also crucial for the results. In a neo-classical model lower marginal revenues of enterprises lead to employment losses if real wages are fixed. Additional employment will only be created if real wages decrease to such an extent that the decrease allows to pay for persons additionally employed. In a Keynesian model employment depends on effective demand. If an ecological tax reform induces additional demand employment will increase.

Studies concluding that an ecological tax reform results in a negative net effect on employment usually put high weight on the mechanism of a relocation of production of energy-intensive sectors. This applies to the RWI-investigation quoted above. The importance of this mechanism is controversially debated, however (DIW/RWI 1993). The assumption on the strength of this mechanism interacts with that on the design of the ecological tax reform: it is obvious that in case of a high sensitivity of international investment flows with respect to international tax differentials a recycling of revenues to reduce capital taxes would lead to a more favorable (or less unfavorable) estimate of employment effects.

A final example demonstrates the importance of taking into account possible innovative effects of environmental policy along with other, though less important, conditions (DIW, ISI 1995). If an ecological tax reform does not succeed in promoting innovation in such a way that overall productivity increases, then the costs of greenhouse gas emission reductions have to be born by consumers as a reduction of their real disposable income. Production and employment increase slightly at best in this case (mainly as a consequence of the additional investment required). If greenhouse gas emission reductions encompass an overall modernization of the economy to the effect of an increase of productivity which would allow to pay their costs, an increase in production could be expected (Figure 5). At higher labour productivity increased production would not go along with higher employment, however.

**Figure 5**




## 3.3 Employment Impacts of an Accelerated Diffusion of Heat Exchangers

It has been argued that the results of impact studies of environmental policy rely on the assumptions made and on the mechanisms included in the respective analyses. This can also be demonstated by an approach which allows to analyze the economic impacts of specific environmental protection technologies and which empirically relies on the inclusion of micro-oriented data, namely engineering-economic data. Special emphasis is given to a detailed modeling of existing production technologies and of feasible alternative technologies. Input-output analysis seems to be especially well-suited for this type of investigation. It allows a detailed representation of technologies in an economic framework and at the same time permits a consistent aggregation of this

detailed information to macroeconomic variables. As analytic framework we apply a dynamic input-output model. To demonstrate the approach the results of a study (Edler 1993) investigating the economic impacts of an accelerated diffusion of heat exchangers in the German economy for the period 1990 to 2000 are reported.

Experts agree that recuperation of waste heat is the most efficient technology for energy saving in the field of industrial processes. In many industrial processes the waste heat has a considerably higher level of temperature than the fresh air or fluid which is used as an input for the technical process. As a result, it is often highly efficient to recuperate the energy contained in waste heat with the help of appropriate devices. Devices which recuperate energy from waste heat are labeled as heat exchangers. From a technological point of view there are different types of heat exchangers, depending on the media from which the waste heat is recovered The distinction is mainly between heat exchangers which extract energy from liquid media or from gaseous, on which this study concentrates.

To analyze the impacts of "heat exchanger" requires the description and modeling of this technology on the supply side (production of heat exchangers) and on the demand side (impact of the application of this technology in using industries) using micro-oriented engineering-economic information.

The accelerated diffusion of the environmental protection technology heat exchangers results in a change of production cost in user industries. The capital costs increase due to the additional investment in the new technology. Compared to the baseline projection the additional amount of investment in heat exchangers amounts to 6.7 Bill. DM (in constant prices of 1980). The main investors (main adopters of the new technology) are the sectors iron and steel (34% of the additional capital stock), food products (23%), stones and clays (18%) and chemical products (11%). The additional production of heat exchangers induces more employment in the producer sector and in those sectors delivering intermediate and capital goods for the production.

But at the same time the input of intermediate goods delivered by other sectors is also changing. This change of energy costs is modeled in a way, that the energy savings in each user sector depend in each period on the rate of adoption of heat exchangers in each sector. The resulting indirect effects are captured by the input-output method. The amount of saved end-use energy is

defined by several technical parameters of the employed devices, e.g. the energy efficiency of the heat exchanger and the time of operation per year, which varies between the user industries. First of all the recuperation of waste heat effects the energy inputs of user industries. The saved energy costs increase from 300 mill. DM in the year 1991 to 8.7 bill. DM in the year 2000. The biggest savings occur in the sectors iron and steel and food products. From the viewpoint of energy producing sectors these energy savings represent a decrease of demand for their products and therefore lower production and employment in these sectors. The lower economic activity has, of course, repercussions in the whole economy, especially in those sectors which deliver products and services to the energy producing sectors.

If one ignores the fact, that the cost savings, which result from the new technology, will not simply vanish from the economic circuit, but open up the potential of new impulses for the economy, one would get negative impacts from the accelerated diffusion of heat exchangers. In this unrealistic case the negative impact on employment would amount to a yearly average of 60 000 persons in the period 1996 to 2000.

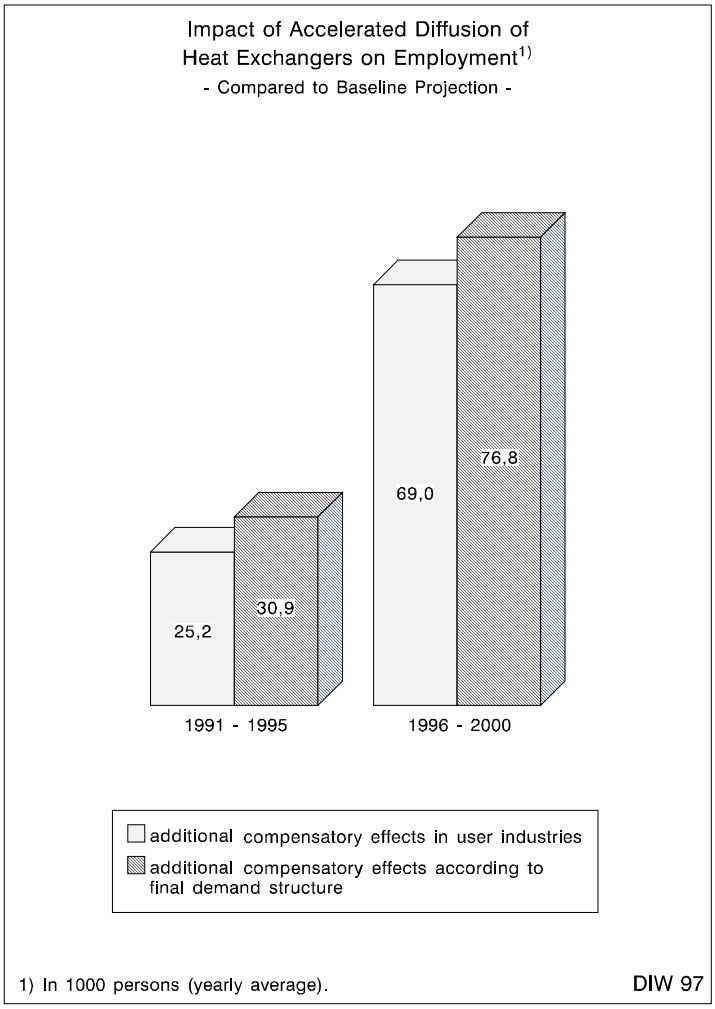
To assess the probable magnitude of the effects of cost savings in the user industries two simulation experiments are performed. In the first simulation experiment labeled as "additional compensatory effects in user industries" it is assumed, that the total saving of costs is used to reduce prices for goods produced in the user industries and that those price reductions are completely compensated by an increase in demand for those goods.

In the second simulation experiment labeled as "additional compensatory effects according to final demand structure" it is assumed that the cost reductions will remain in the companies of the user industries as additional income. This income has to be distributed to labour and capital income. The latter may be used, e.g. as additional investment. After redistribution according to the prevailing tax and social security system and after taking into consideration the saving rate for this additional income the overall demand for goods in the economy may eventually increase. The sectoral structure of increased demand depends on the marginal demand elasticity for specific goods. For the sake of clarity it is assumed that the total amount of cost reduction to be transferred as income to labour and capital. We neglect redistributional effects and assume that the marginal saving rate for this additional income is equal to zero. The additional demand is

distributed to the different sectors according to the structure of final demand in each year of the simulation period, thus implicitly assuming a marginal sectoral demand elasticity of one.

In reality, however, the effective compensating mechanisms will be a mixture of the possibilities discussed above.Taking in to account these compensatory effects the accelerated diffusion of heat exchangers results in positive employment effects. These positive effects are fueled by a

**Figure 6**




temporary increase of investment in the user industries and by a permanent substitution of (energy) imports by domestic production. In addition the structure of gross production changes in a way that the weight of the capital intensive energy producing sectors decreases while the weight of more labour intensive sectors increases.

The yearly average of the positive employment effect for the period 1996 to 2000 amounts to about 70 to 75 thousand persons (see Figure 6). There are, however, sectors in which the employment effect will be negative, especially in the energy producing sectors like electric power generation and products of mining. In the majority of sectors the employment effects are positive. The users industries have the biggest positive impact on employment, if ones assumes that they use their cost reductions for price reductions for their products. In the other case, where the cost reductions are distributed as income to labour and capital, the biggest positive effects occur in sectors, which produce primarily consumer goods.

## 4 Conclusions

Environmental labour market analysis poses a variety of methodological difficulties. If these are neglected or dealt with inadequately misunderstandings and misguidance of policy may be the consequence. First of all, it is essential to distinguish between counting the number of jobs induced by environmental protection activities and assessing the net impact of environmental policy on employment. Answering the second question requires to hypothetically compare situations where the policy action to be evaluated is taken versus one where it is not enacted. Counting the number of environmental jobs is more straightforward in priciple but poses many problems of delimitation and data collection in practice.

Problems of delimitation start with the very notion of environmental protection; it can be savely said that hardly any two estimates of environmental jobs are based on exactly the same understanding of what environmental protection is. Further problems of delimitation - described in detail in the present paper - arise when accounting for the amount of labour contained in goods used directly and indirectly in the production of environmental services. We conclude that it is essential to present along with the figures detailed information on the delimitations underlying any particular estimate of environmental employment.

Problems of delimitation overlap to a significant degree with problems of data collection, but more fundamental difficulties are created by the fact that environmental protection activities as well the production of goods applied in such activities cut across standard industrial classifictions. Two different methodologies - a supply side approach and a demand side

approach - have been developed in response. The present paper discusses their relative strenghts and weaknesses. We conclude that an integration of the two approaches in a way which allows for cross checking - supplemented by engineering and case study data when appropriate - seems to be a promising way for future analysis of employment induced by environmental protection.

The balance of jobs created by environmental policy actions can only be determined through model simulations. By their nature models are unable to simultanously capture all of the many complex mechanisms by which environmental protection and employment are linked. Depending on which mechanisms are taken into account the conclusions on the employment effects of environmental policy actions may even differ with respect to their direction. In addition, models incorporate often implicit assumptions on important framework conditions such as the reaction of monetary policy. A further source of disagreement is that the models applied for environmental labour market analysis usually do not describe the link between legal and administrative arrangements and their economic consequences but just the secondary and tertiary effects triggered by the latter; thus the primary economic impulses of environmental policy have to be determined exogenously outside the model.

It does not seem appropriate to suggest any standard procedure for determining the net employment effects of environmental policy. It is essential, however, to clearly state the impulses, the framework conditions and the mechanisms underlying any particular result. In addition, such results should routinely be presented along with sensitivity analyses showing the responsiveness to variations of essential assumptions. Finally, the user wanting to draw conclusions from such results should be aware that all he can hope for is a mosaic-like picture to which every single study can contribute only another piece.

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