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Fondazione Eni Enrico Mattei

## **Structural Change and Environmental Kuznets Curves**

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CLIM – Climate Change Modelling and Policy

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# Structural Change and Environmental Kuznets Curves

## Summary

The Environmental Kuznets Curve hypothesis (EKC) postulates an inverted u-shaped curve between important pollutants and per capita GDP analogous to the relationship between income inequality and income per capita which has been analysed by Kuznets in 1955. The article focuses on an empirical analysis of structural change between branches as one major determinant of EKC's. The results of a cointegration analysis show that amongst other determinants the decline of environmental intensive branches in Germany during the last decades can be econometrically explained by the development of energy prices and the so-called Fourastié hypothesis.

**Keywords:** Structural change, environment, environmental policy

**JEL:** O13, Q20, C22

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## 1. Introduction

For about ten years there has been a growing debate about the Environmental Kuznets Curve hypothesis (in the following EKC). The EKC postulates an inverted u-shaped curve between important pollutants and per capita GDP analogous to the relationship between income inequality and income per capita which has been analysed by Kuznets in 1955<sup>1</sup>. Concerning the environment an EKC describes hence a time path characterised initially by a positive correlation between pollutants and GDP becoming negative during a later phase of the economic development of a country.

A great part of the literature was concerned with the analysis of the existence of EKC's.<sup>2</sup> For pollutants such as sulphur dioxides or the energy intensity of production EKC's could be found whereas for other environmental problems like the production of waste positive correlations between economic growth and environmental impacts could be observed.<sup>3</sup> In the following it is not the aim to produce an additional article to the never ending debate about the existence of EKC's but it is more interesting to analyse the driving forces leading in some cases to the appearance of EKC's and in other cases to opposite results.

Only few articles have dealt with theoretical and empirical explanations of EKC's.<sup>4</sup> In section 2 a survey of this literature will be given. The focus of present article consists in a detailed analysis of structural change between branches as one of the main (potential) determinants of EKC's. Section 3 summarizes the main theoretical explanations leading to an "ecological" structural change. Section 4 and 5 contain empirical and econometrical evidence.

## 2. Determinants of the EKC: A survey of the literature

Empirical analyses of EKC relationships for different pollutants show that economic growth does not automatically lead to improvements of environmental quality.<sup>5</sup> "It follows that the EKC-hypothesis can not give a freeway for unlimited economic growth because it may not be economic growth itself that causes emissions to decline".<sup>6</sup> For that reason it is very important to analyse the driving forces of the EKC relationship. In the present section a survey of the literature is provided.

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<sup>1</sup> Kuznets (1955).

<sup>2</sup> See for example Grossman/Krüger (1995), Selden/Song (1995), Egli (2002).

<sup>3</sup> Galeotti/Lanza (1999).

<sup>4</sup> De Bruyn (1997 or 2000), Rothman (1998), Suri/Chapman (1998).

<sup>5</sup> Galeotti/Lanza (1999).

<sup>6</sup> De Bruyn (1997), p. 1.

Magnani discusses the influence of income inequality in connection with political economic reasons for the existence of EKC. She argues that income inequality in a country determines the position of the median voter demanding environmental expenditures. A high degree of income inequality leads to a median voter having only little preferences for green parties. As a consequence environmental expenditure in the considered country will be low. The author states that “the empirical results point to a positive absolute income effect and a negative impact of income inequality on environmental protection”.<sup>7</sup>

Rothman favours a consumption based approach in connection with the so-called pollution haven hypothesis. Consumers in wealthy nations succeed more than others in distancing themselves from environmental problems by international trade.<sup>8</sup> The richer a country the production of pollution intensive goods will be more and more dislocated in poor countries with lax environmental regulations. For that reason the author regards more consumption oriented environmental indicators such as CO<sub>2</sub> emissions or municipal waste. Rothman shows that for these indicators EKC’s do not appear whereas production-based indicators proof the existence of EKC’s. The analysis of Rothman is supported by Gawande, Bohara, Berrens and Wang<sup>9</sup> who test the role of internal migration as a factor for the appearance of EKC’s for US hazardous waste sites with respect to the fact that primarily rich people are able to migrate.

Another argumentation is given by Andreoni und Levinson: The authors show that „... an environmental Kuznets curve can be derived directly from the technological link between consumption of a desired good and abatement of its undesirable by-product“. They assume that scale effects of environmental technologies play a major role in explaining EKC’s. „As an economy grows, more and more industries and manufacturing facilities become large enough to make the capital investment in abatement technologies worthwhile“. <sup>10</sup>

De Bruyn carries out a decomposition analysis to find out the relative importance of intrasectoral changes with respect to structural changes between branches. Intrasectoral changes denote “... the combination of technological change and shifts in the product mix within sectors”.<sup>11</sup> For the case of sulphur dioxide with respect to Germany and the Netherlands from 1980 to 1990 de Bruyn emphasizes the role of technical progress within sectors for the appearance of EKC’s whereas inter-sectoral structural change was not significant in his analysis. Suri and Chapman measure the influence of structural change between branches (variable “share of manufacturing”), trade and especially the role of imports for the downward slope of

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<sup>7</sup> Magnani (2000), p. 432.

<sup>8</sup> Rothman (1998).

<sup>9</sup> Gawande/Bohara/Berrens/Wang (2000).

<sup>10</sup> Andreoni/Levinson (1998), p. 13.

<sup>11</sup> De Bruyn (1997), p. 7.

EKC's for pooled cross-section and time series data of 33 countries from 1971 to 1991. Contrary to the results of de Bruyn they found a significant influence of inter-sectoral changes on energy consumption.<sup>12</sup>

In an econometrical analysis Agras and Chapman show a strong negative influence of energy prices for the development of CO<sub>2</sub> emissions and energy consumption.<sup>13</sup> In a further empirical analysis for 23 countries Kaufmann, Davidsdottir, Garnham and Pauly find out that "... spatial intensity of economic activity, rather than income, provides the impetus for policies and technologies that reduce SO<sub>2</sub> emissions".<sup>14</sup>

Torras and Boyce (1998) analyse the importance of literacy, political rights and civil liberties as main factors of EKC.<sup>15</sup>

It has to be noticed that there is a lack of research concerning the role of environmental policy. Furthermore structural change between branches is only regarded as one factor of EKC's but it would be more important to analyse the interaction of structural change with other factors which will be shown in the next section.

### **3. Determinants of ecological structural change between branches**

The paper of Suri and Chapman has shown that structural change between branches has been an important determinant of EKC's.<sup>16</sup> But structural change is only useful as explanatory variable and for policy recommendations when we know something about the driving forces lying behind the composition of an economy. The main focus of the present section is to investigate theoretical explanations leading to structural change of the economy with positive effects for the environment. In the following this development will be called "ecological structural change".

There is no comprehensive theory of economic structural change up to now so that we have to combine different theoretical explanations.

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<sup>12</sup> Suri/Chapman (1998).

<sup>13</sup> Agras/Chapman (1999).

<sup>14</sup> Kaufmann/Davidsdottir/Garnham/Pauly (1998).

<sup>15</sup> Torras/Boyce (1998).

<sup>16</sup> Suri/Chapman (1998).

### *Three Sector Hypothesis of Fourastié and the environmental intensity of the service sector*

Fourastié postulated a relationship between the per capita GDP and the economic structure of a country.<sup>17</sup> He observed an upward trend of the service sector which can be explained by different sectoral income elasticities of demand in connection with a growing per capita income leading to an increasing demand for products of the service sector. Concerning primary products like food the low income elasticity of demand causes a reduction of the share of expenditure with respect to total expenditure when the per capita income increases (law of Engel). Furthermore the labour productivity of the production of industrial goods increases and leads to unemployment in the primary and secondary sector. The unemployed try to get new jobs in the job intensive service sector. A necessary condition for the relative growth of the service sector is that the income elasticity for services is greater than one (demand bias hypothesis).<sup>18</sup>

The demand and the productivity hypothesis together lead to a change of the employment structure in the direction of more services. When we take account of the fact that the service sector is less environmental intensive compared with the production of industrial goods the Fourastié hypothesis represents a built-in-force for the EKC hypothesis.

This effect will be reinforced when environmental awareness rises together with the growth of the per capita income - a phenomenon which could be observed in many industrialized countries.

### *Product cycles*

In most cases a higher degree of development of an economy is accompanied by more and more advanced and intelligent products which are less environmental intensive, for example software products with comparison to steel.

### *Environmental policy, external shocks*

The main task of environmental policy consists in the internalisation of negative external effects of environmental relevant activities of enterprises and consumers. For example eco-taxes can lead to a decline of the share of energy intensive branches by correcting the relative factor

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<sup>17</sup> Fourastié (1954).

<sup>18</sup> Beissinger (2000).

prices with respect to other branches. External shocks like an increase of oil prices can lead to similar effects so that we can describe these shocks as “imported environmental policy”.

Furthermore it can be empirically shown that institutional changes (e. g. the foundation of the ministry of environmental affairs in Germany in 1986) help to increase the importance and the efficiency of environmental policy.<sup>19</sup>

### *Technical progress*

Within neoclassical growth theory technical progress is the most important determinant of economic growth. Structural change between branches can be derived from different rates of technical progress in the different branches. Besides further arguments endogenous growth theory tries to explain the technical progress by emphasizing the positive role of the development of human capital.<sup>20</sup> The question if technical progress then causes a less environmental intensive production structure can only be answered empirically. It can be shown (see also next section) that during the past decades less environmental intensive branches like electrical engineering or the communication industry were research and human capital intensive so that technical progress led to a environmental friendly industry structure in Germany.

### ***Ecological structural change: Summary of empirical provable hypotheses***

*Non-environmental related determinants leading to a lower environmental intensity of production:*

- Product cycles: Many environmental intensive goods are at the end of their product cycle;
- A growing per capita GDP together with an increase of labour productivity causes a rise of the share of the service sector (Fourastié);
- External shocks like the two crisis of oil prices in 1973 and 1981 induce an environmental friendly structural change because of the change of relative factor prices.

*Environmental measures like regulation policy or eco taxes induce ecological structural change:*

- Environmental measures promote environmental innovation;
- Regulations and eco taxes favour environmental friendly branches.

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<sup>19</sup> Horbach (1992).

<sup>20</sup> Aghion/Howitt (1998).



#### 4. Descriptive analysis of ecological structural change

In the following the theoretical determinants of an ecological structural change will be empirically tested by a descriptive and an econometric analysis for West-Germany from 1960 to 1997. There is no comprehensive indicator for environmental pollution so that EKC's can only be found for single pollutants or energy consumption. From 1960 to 1995 the growth of GDP in Germany was accompanied by a strong reduction of sulphur dioxide emissions and also of nitric and carbon oxides.<sup>21</sup> Energy consumption has only augmented by the factor 1,7 from 1960 to 1990 whereas the GDP grew two times and a half during the same time period.<sup>22</sup> Contrary to these findings a linear and positive correlation between GDP and land use or waste water disposal can be discovered.<sup>23</sup>

In the following we want to find out if the sectoral structure of the German economy has become less environmental intensive. For that reason we need a measure of the environmental intensity of a branch. Because of the lack of an overall environmental indicator we will use pollution abatement investment as a proxy for environmental intensity. This indicator makes it possible to summarize different environmental problems to one monetary unit. It is evident that this indicator records only internalised external effects but on the other side the most important environmental problems in Germany are regulated by the state.

In the context of this analysis branches are declared as environmental intensive if the percentage of the pollution abatement investment with respect to all investment of the considered branch was - on average - higher than 5% from 1993 to 1997. The following branches are concerned:

- Electricity, gas and district heating;
- Minery;
- Processing of mineral oil;
- Non-metallic minerals, construction materials;
- Metal industry: production of iron, aluminium, foundry;
- Chemical industry;
- Processing of wood;
- Production of zellulose, paper and cardboard;
- Leather and textiles.

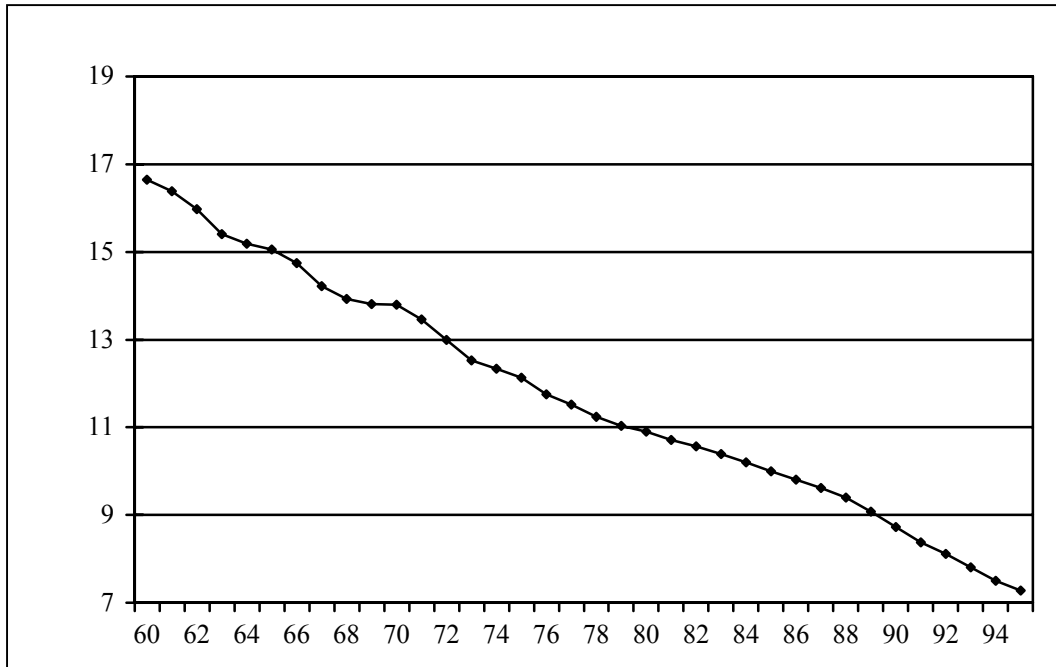
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<sup>21</sup> Weber (1999), p. 14.

<sup>22</sup> Kuhn/Radermacher/Stahmer (1994), p. 667.

<sup>23</sup> Kuhn/Radermacher/Stahmer (1994), p. 672-674.

Figure 1:  
Employment share of environmental intensive branches in West-Germany from 1960 to 1995  
- in % -



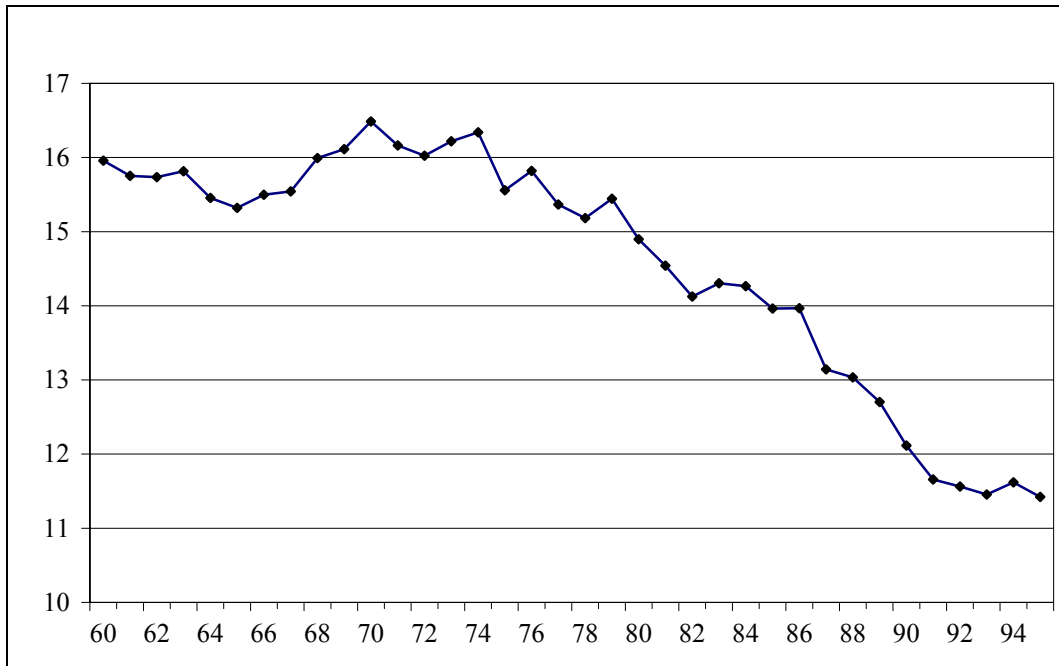
Source: Time series service of the statistical office, own calculations.

In West-Germany the employment share of the environmental intensive branches has diminished from 1960 to 1995 (see figure 1).<sup>24</sup> Because of high productivity gains these branches succeeded in keeping their relative importance of 16% with respect to real GDP up to 1973. From 1973 to 1995 this value decreased to 11 % (see figure 2).

A breakdown by single environmental intensive branches points to possible determinants of ecological structural change. Among the environmental intensive branches the shares of the „old industries“ have primarily diminished, the products of these branches are more and more at the end of their life cycle (see figure 3). This is especially valid concerning the branches minery, metal industry, processing of mineral oil and leather and textiles. Concerning these branches not environmental policy but other reasons were probably responsible for their decline. Despite high environmental costs the GDP share of the chemical industry remained constant. Only the employment share declined during the last years (see figure 4).

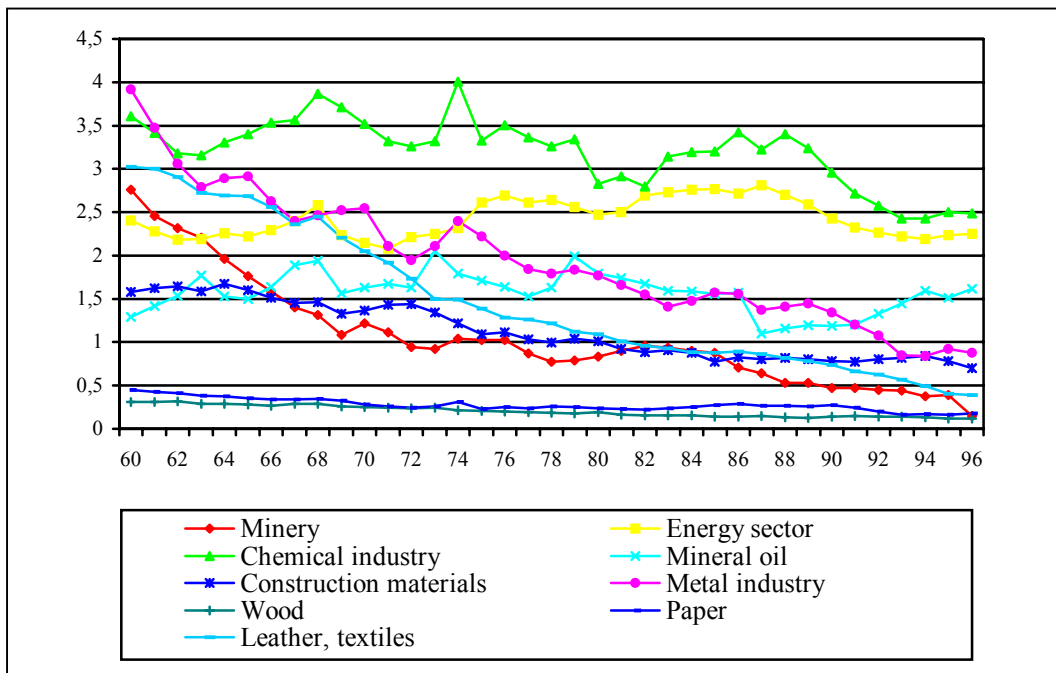
<sup>24</sup> It is important to notice that regarding the time period from 1960 to 1998 we can only observe the down-sloping parts of EKC's but not the typical hump-shaped pattern.

Figure 2:  
Share of environmental intensive branches on real GDP in West-Germany from 1960 to 1995  
- in % -



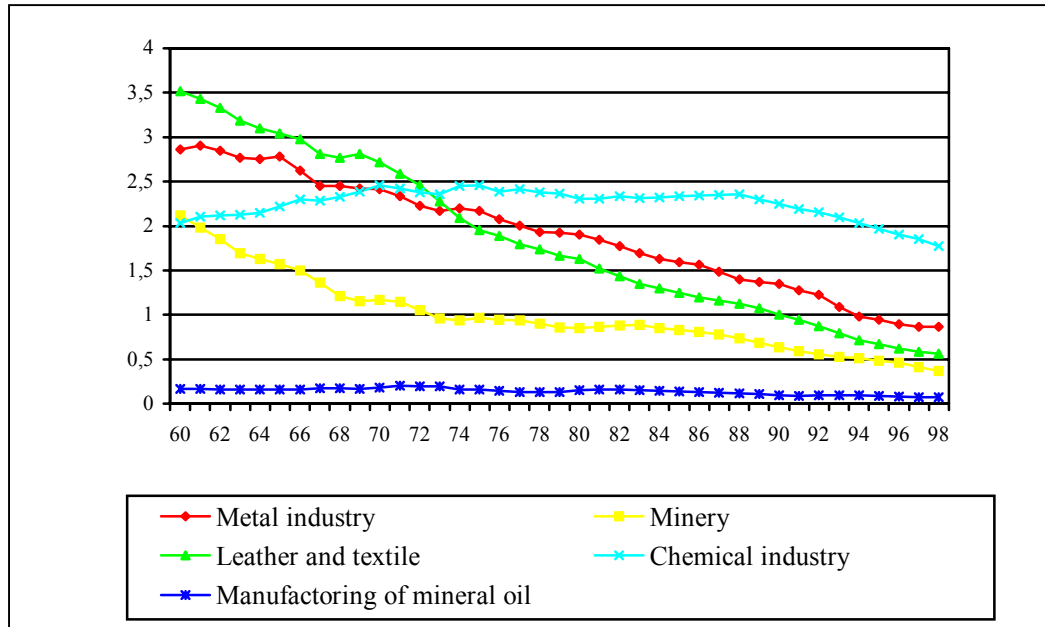
Source: Time series service of the statistical office, own calculations.

Figure 3:  
Share of environmental intensive branches on real GDP in West-Germany from 1960 to 1996  
- in % -



Source: Time series service of the statistical office, own calculations.

Figure 4:  
Employment shares of different environmental intensive branches in West Germany from 1960 to 1998 - in % -



Source: Time series service of the statistical office, own calculations.

The development of the shares of the individual branches can have very different reasons. E.g. the worldwide relevance of minery has declined whereas the problems of leather and textiles are characterised by a loss of competitiveness of the German enterprises because of high wage costs which led to a removal of establishments in low wage countries.

For that reason it will not be useful to summarize the environmental intensive branches to one aggregate but we will regard separately the most important branches in the next section.

## 5. Econometric analysis of ecological structural change

In the following econometric analysis provable indicators have to be developed which can be used to test the above mentioned determinants of ecological structural change. The possibilities of this analysis are restricted by data availability (see table 1).

### *Choice of indicators*

Long time series data for proving the product cycle hypothesis and the influence of international competitiveness were not available. With respect to international competitiveness exchange rate variations were used as an indicator.

For technical progress changes of labour productivity has been used as a proxy. Indicators like “new patents”, “number of new products”, R&D costs or R&D employees are not available for the considered time period.

Table 1:

Empirical indicators for the determinants of structural change between branches

<b>Economic Variable</b>	<b>Statistical indicator</b>	<b>Remarks</b>
International competitiveness of the branch	RCA-values, world market shares Influence of exchange rates	Not available for the considered time period
Fourastié-hypothesis: Influence of GDP per capita	GDP/population Labour productivity	
Environmental awareness	Number of environmental relevant articles in „Der Spiegel“	
Environmental policy	1) Number of environmental relevant articles in „Der Spiegel“ 2) Environmental investment by branches as output indicator of environmental policy 3) Energy cost	These statistics are only available since 1975 so that they cannot be used in the cointegration analysis Energy prices are used but they can only partly derived from environmental policy
External shocks	Energy price index representing the influence of oil crises	
Non-neutrality of sectoral technical progress	Labour productivity R&D-expenditure, R&D-employees	only available for several years

Concerning the hypothesis of Fourastié the data basis is sufficient because there are time series for the per capita GDP and the labour productivities by branches. For a branch of the secondary sector the hypothesis of Fourastié is confirmed when increases of the per capita GDP and the labour productivity lead to a decrease of the employment share of this branch.

For measuring the influence of environmental awareness and environmental policy the indicator „number of environmental relevant articles in “Der Spiegel” has been used. In empirical studies it could be shown that many environmental policy measures have been carried out in reaction to a more widespread publicity of an environmental problem.<sup>25</sup> The catalytic converter e. g. has been introduced after a long public debate supported by the different media.

On the other side the influence of environmental policy can also be measured by the development of energy prices. Facing the two great oil crises in the seventies and the eighties this variable was very important for the development of energy saving and environmental friendly techniques but only partly due to environmental policy. It is possible to describe this phenomenon as an “imported” environmental policy. An econometric analysis using energy prices as independent variable will however give some hints for the efficiency of eco-taxes.

In the following it has to be decided if nominal or real GDP or employment shares can be used as endogenous structural change variable.

Nominal shares draw a realistic picture of the sector structure of an economy because in most cases the success of a branch can also be measured by the extent of the possibility to impose higher prices.<sup>26</sup> On the other side it is possible that exogenous influences like oil crises or eco-taxes lead to price increases that are not due to the economic performance of the branch. As a consequence the influences of environmental policy on the GDP share of the branch can hardly be measured because on the one hand environmental policy leads to a deterioration of the competition position of the branch but on the other hand to an increase of the nominal GDP share when the price elasticity of demand is low.

Real GDP shares avoid partly this problem but the sector structure of the economy is strongly dependent from the choice of the base year when using long time series. If we use for example a base year in the nineties the relative importance of the textile industry in the sixties will be underestimated because this branch had undergone a strong decline of the prices.<sup>27</sup>

A third indicator consists in employment shares. Because of differing labour productivities by sectors the economic success of the branch is not correctly described. For the examination of the hypothesis of Fourastié this is indeed not important. Within the following cointegration analysis employment shares will be mainly used. Labour productivity will be included as independent variable.

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<sup>25</sup> Horbach (1992).

<sup>26</sup> Blien (2001).

<sup>27</sup> Gornig (2000), p. 49.

*Results of the factor- and cointegration analysis*

The following econometric analysis tries to show why environmental intensive branches have lost much of their relative importance during the last decades. For this purpose the most important environmental intensive branches will be analysed by using the method of multivariate cointegration analysis. Because of the existence of different determinants for the several branches an aggregation is not appropriate.

The variables used within this analysis are non-stationary so that multivariate regression analysis would not be the appropriate method because of the possibility of spurious regressions. Even the use of first differences is not useful because structural change is a long-term phenomenon.

Table 2: Description of the variables

Variable name	Description of the variable
SHAREMET	Employment share of the metal industry
SHAREMIN	Employment share of minery
SHARELT	Employment share of leather and textiles
SHARECH	Employment share of the chemical industry
SHAREOIL	Employment share of manufacturing of mineral oil
SHAREEL	Employment share of electrical engineering
SHARESER	Employment share of the service sector
PRODMET	Real labour productivity of the metal industry (in prices of 1991)
PRODLT	Real labour productivity of leather and textiles (in prices of 1991)
PRODCHEM	Real labour productivity of the chemical industry (in prices of 1991)
PRODOIL	Real labour productivity of manufacturing of mineral oil (in prices of 1991)
PRODEL	Real labour productivity of electrical engineering (in prices of 1991)
PRODSER	Real labour productivity of the service sector (in prices of 1991)
ERDMDOLL	Exchange rate DM/\$
ENERGPR	Energy price index
PERCGDP	Per capita GDP in prices of 1991
SPIEGEL	Number of environmental relevant articles in „Der Spiegel“
WAGEMET	Wage differential of the metal industry
WAGEEL	Wage differential of the electrical engineering
TREND	Time trend

A cointegration analysis requires variables characterized by the same order of integration.<sup>28</sup> Following the results of Advanced Dickey Fuller Tests (ADF) all included variables contain

<sup>28</sup> Enders (1995), p. 374.

an integration level of one (I(1)), so that cointegration analysis is possible. The widespread method of Johansen has been used.<sup>29</sup>

The short-term dynamics will not be reported because cyclical fluctuations are not interesting with respect to the theoretical explanations of structural change.<sup>30</sup> To avoid multicollinearity and to reduce the number of variables in the cointegration analysis factor analyses were carried out.<sup>31</sup>

Cointegration relationships were estimated for the most important environmental intensive branches. Additional cointegration analyses were executed for environmental friendly branches to get some further insights in the ecological structural change.

### *Metal industry*

The results of the cointegration analysis confirm the hypothesis of Fourastié. An increasing GDP per capita and labour productivity in the metal industry were accompanied by a declining share of employment. The variable FACMET derived from a factor analysis (table 3) representing inter alia the real GDP per capita and the labour productivity shows a negative sign (table 4).

Table 3: Results of the factor analyses

Branches	Factor	Factor loadings in brackets
Metal industry	FACMET	PERCGDP (0,999); ERDMDOLL (-0,897); PRODMET (0,972); ENERGPR (0,923); SPIEGEL (0,883)
Minery	FACMIN	PERCGDP (0,971); ENERGPR (0,971)
Leather/Textiles	FACLT	PERCGDP (0,993); ERDMDOLL (-0,934); PRODLT (0,955); ENERGPR (0,912); SPIEGEL (0,992)
Mineral oil	FACOIL	PERCGDP (0,985); ERDMDOLL (-0,962); PRODOIL (0,914); ENERGPR (0,930)
Electrical engineering	FACEL	PERCGDP (0,985); ENERGPR (0,964); SPIEGEL (0,912); PRODEL (0,994)
Service sector	FACSER	PERCGDP (0,996); PRODSER (0,998); SPIEGEL (0,887); ENERGPR (0,949)

In addition the results are showing a negative influence of energy prices as “environmental variable” on the relative importance of the metal industry. The development of environmental awareness is also correlated with the decline of the metal industry. Furthermore the sign of the

<sup>29</sup> Johansen/Juselius (1990); Johansen (1995).

<sup>30</sup> Furthermore a new empirical study has shown that short term dynamics between income changes and environmental pollutants in Germany were not significant (Egli (2002), S. 18).

<sup>31</sup> Backhaus/Erichson/Plinke/Weiber (1990).



exchange rate variable ERDMDOLL shows the dependance of the metal industry from exports. A devaluation improves the competitiveness of the metal industry and increases its employment share.

Table 4: Results of the cointegration analysis

Branches	Results of Johansen Cointegration Tests*	Cointegration equations (t-values in brackets)
Metal industry	H0= None: 31,4 (29,7; 35,7)	1,00 SHAREMET + 0,66 (13,57) FACMET – 0,02 (-1,86) WAGEMET + 0,22
Minery	H0=None: 30,9 (15,4; 20,0)	1,00 SHAREMIN + 0,11 (2,44) FACMIN – 0,97
Leather/Textiles	H0=None: 22,6 (20,0; 24,6)	1,00 SHARELT + 0,89 (6,60) FACLT - 3,10
Chemical industry	H0=None: 18,4 (15,4; 20,0)	1,00 SHARECH - 5,15 (-5,59) PRODCHEM + 165,30
Mineral oil	H0=At most 1: 4,6 (3,8; 6,7)	1,00 SHAREOIL + 0,02 (2,79) FACOIL - 0,15
Electrical engineering	Ho=None: 30,3 (21,0; 25,5)	1,00 SHAREEL - 0,88 (-8,22) FACEL + 0,11 (7,53) WAGEEL -18,11
Service sector	H0=None: 30,0 (25,3; 30,5)	1,00 SHARESER - 35,75 (-2,0) FACSER + 2,9 (1,68) TREND -57,1

\*Johansen test results: The numbers in brackets are the critical values at 5% and 1% levels

The variable WAGEMET is also significant. This variable describes the distance of the sum of wages per employee in the metal industry with respect to the corresponding variable of the whole economy. For Smolny this variable can serve as an indicator for the relative equipment with human capital for a branch because „... a substantial part of inter-industry wage differentials can be attributed to observable, human capital related characteristics of the work force. ... The relative sectoral human capital can appropriately be approximated by relative sectoral wages.<sup>32</sup> Following the results of the new growth theory a good equipment with human capital is a sign of a high innovation potential of a branch. Although the significance of the variable WAGEMET is only weak the positive influence on the employment share of the metal industry shows that despite rationalization effects more „intelligent“ production methods have been profitable for the employment share of the metal industry.

<sup>32</sup> Smolny (2000), p. 21 and p. 27.

### *Minery*

The Fourastié hypothesis has also been confirmed for the minery which can be shown by the sign of the variable FACMIN derived from a factor analysis (table 3). An increase of the per capita GDP leads to a decline of the employment share of the minery. But there is no significant influence of labour productivity. This variable has increased up to 1973 but probably the two oil crisis lead to a strong decline up to the middle of the eighties. In connection with the influence of high subsidies the minery was less forced to rationalize employees.

### *Leather and textiles*

Concerning leather and textiles the Fourastié hypothesis could be confirmed by a factor and cointegration analysis. Furthermore a negative influence of energy prices as „environmental variable” could be observed. The performance of the branch is clearly dependent from influences of foreign trade. A depreciation of the German Mark has encouraged the development of the branch. The weak significance of the cointegration approach for the leather and textile industry is probably due to the lack of data for important determinants. Relative high wages in comparison to foreign countries can have led to a capital flight to these countries.

### *Chemical Industry*

Concerning the chemical industry the Fourastié hypothesis can not be confirmed by the econometric analysis. The environmental variable has no significant influence, too. Accompanied by high productivity increases the chemical industry has succeeded in defending its real GDP share whereas the employment share has declined (see also section 4).

### *Processing of mineral oil*

Because of the substitution of coal by oil the employment shares of the “processing of mineral oil” increased from 1960 to 1973. After 1973 the importance of the processing of mineral oil declined because high energy prices as a consequence of oil crises led to a reduction of energy consumption which forced the mineral oil sector to save costs by reducing the employment.

*Electrical engineering*

The results of the factor and the cointegration analysis show positive influences of energy prices, per capita GDP, labour productivity and environmental awareness. Except low growth rates during the nineties the electrical engineering which is not environmental intensive belongs still to one of the growing industries in Germany. The variable WAGEEL describing the distance of wages in this industry with respect to all wages has increased from 1975 up to now. The negative sign of this variable suggests that electrical engineering has specialized in human capital intensive fields which was accompanied by a decline of employment intensive fields.

*Service sector*

The environmental friendly service sector is characterized by a statistical significant confirmation of the Fourastié hypothesis. Increases of energy prices and environmental awareness were positively correlated with a growing importance of this environmental friendly sector.

**5. Summary**

So far as data was available structural change as one major determinant of EKC's has been analysed for Germany from 1960 up to now. It was not the aim to quantify the ecological effects of structural change but to recognize the driving forces leading to a less environmental intensive sectoral structure of an economy.

Energy prices indicate the importance of environmental measures for structural change although their increases were mainly due to exogenous influences (e. g. oil crises) and not to environmental policy. The econometric analysis has shown that higher energy prices led to a decline of the relative importance of environmental intensive branches.

For all environmental intensive branches a negative influence of the per capita GDP on employment shares was observable. In connection with the development of labour productivities the hypothesis of Fourastié has been confirmed in these cases.

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