To my family and the memory of my father

ON THE MEASUREMENT OF PRODUCTIVITY AND ENVIRONMENTAL EFFICIENCY IN THE PRESENCE OF THE JOINT PRODUCTION OF GOODS AND BADS: AN APPLICATION TO OECD COUNTRIES

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ABSTRACT

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Productivity measures, which do not account for environmental performance, are biased. When it comes to incorporating the developments in environmental performance into the measurement of productivity, the traditional "Tornquist type" indices fail to measure the productivity particularly in the cases where price information on undesirable outputs do not exist. Therefore, there is a need for an alternative measure which puts due emphasis on production with negative externalities without requiring price information. Motivated by these facts, this study first employs a Malmquist index for OECD countries without considering the existence of pollutant data and then to overcome the shortfall of this index, a Malmquist-Luenberger productivity index is employed. Furthermore, using an index number approach, environmental performance of OECD countries is also evaluated, by using a method, which relies on the computation of the distance functions within a DEA framework.

Keywords: environmental efficiency index, index numbers, Malmquist productivity index, Malmquist-Luenberger productivity index, OECD countries

ÖZET

FAYDALI VE ZARARLI MADDELERİN BİRLİKTE ÜRETİMİNDE VERİMLİLİK VE ÇEVRESEL PERFORMANSIN ÖLÇÜMÜ ÜZERİNE: OECD ÜLKELERİ ÜZERİNE BİR UYGULAMA

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Çevresel performansı dikkate almayan verimlilik ölçüleri hatalı sonuçlar vermektedir. Çevresel performansı verimliliğe dahil etmeye çalışan klasik "Tornquist" tipi indeksler de zararlı maddelerin fiyat bilgisinin bilinmediği durumlarda verimliliği ölçememektedir. Bu yüzden, fiyat bilgisine gerek duymayan ve zararlı maddelerin üretim sürecinde olduğu durumlarda kullanılabilecek alternatif ölçülere ihtiyaç duyulmaktadır. Bu noktadan hareketle, bu çalışma verimlilik ölçümünde öncelikle OECD ülkeleri için zaralı maddelerin üretim sürecinde var olduğunu dikkate almaksızın Malmquist indeksi kullanır. Daha sonra bu indeksin eksik yönleri göz önünde tutularak Malmquist-Luenberger üretim indeksi kullanılmıştır. Ayrıca OECD ülkelerinin çevresel performansı DEA metodu çerçevesinde uzaklık fonksiyonlarının hesaplanmasına dayanan indeks rakamları yaklaşımıyla ölçülmüştür.

Anahtar Kelimeler: çevresel verimlilik indeksi, indeks rakamları, Malmquist verimlilik indeksi, Malmquist-Luenberger verimlilik indeksi, OECD ülkeleri

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CHAPTER 1

INTRODUCTION

Since the introduction of famous growth model by Solow (1956, 1957), the accurate measurement of productivity and efficiency has been one of the most important and widely discussed issues of economic literature. The Solow model focuses on four variables namely output, capital, labor and "knowledge" or the "effectiveness of labor". According to the model, at any time, the economy has some amounts of capital, labor and knowledge and these are used to produce outputs. Then, simply put, we may say that in any production process, for a given inputs, outputs are produced.

Beyond the theory, individual figures or economic variables of countries do not help us to make comparisons or correctly assess the productivity. For this purpose, we have productivity growth measures or indices. In a very simple manner, efficiency and productivity measurement tell us about how well a firm or a country is doing to relative to some benchmark, which is constructed over the whole sample. By this kind of approach and with the help of productivity indices, we are able to judge the performances of countries relative to the whole sample.

Traditional measures of productivity growth have only concentrated on production of desirable outputs (goods) with no consideration on environmentally hazardous by-products (bads) of the production process. This type of approach typically yields biased measures of productivity growth.

In the light of this fact, recently a substantial literature has emerged to model the productivity growth in the presence of the joint production of goods and bads. One possible approach is to modify the traditional methodology and productivity indices (such as Tornquist and Fisher indices) so as to incorporate the undesirable outputs. However, this requires price information on both desirable and undesirable outputs as well as inputs considered. In this case, a shadow price for each of the pollutants considered should also be computed. For this purpose, shadow prices can be estimated by following Pittman (1983) or Fare et al. (1993).

An alternative approach to measure productivity by incorporating the undesirable outputs is to employ an index that requires information only on quantities. One such index is referred as Malmquist productivity index. However, in the presence of undesirable outputs in production process, this index has to be modified to incorporate negative externalities. Further discussion and explanation of this problem can be seen in Chung et al. (1997). This index is quite popular in the literature and without considering the negative externalities, employed in various studies that use either micro or macro data.

To measure the productivity in the presence of the joint production of goods and bads, Chung et al. (1997) developed a modified version of Malmquist productivity index, which they referred as Malmquist-Luenberger productivity index. This index credits the reduction of undesirable outputs while simultaneously crediting increases in desirable outputs and similar to original Malmquist productivity index, depends on quantities without requiring information on prices. Therefore, this index is a useful alternative in measuring productivity.

This thesis first computes a Malmquist productivity index to measure the productivity growth of OECD countries without considering the presence of the negative externalities. To overcome the shortcomings of the Malmquist productivity index, a Malmquist-Luenberger productivity index is computed which accounts for the pollutants in the measurement of productivity. Then Malmquist and Malmquist-Luenberger indices are compared in terms of their strengths and weaknesses in measuring the productivity.

Furthermore, following Fare et al. (1999) an alternative index is employed which is used to evaluate the environmental performance of the OECD countries. This index, using index number approach and DEA framework, relies on the computations of distance functions and aimed to be a well-established methodology in evaluating the environmental efficiency of OECD countries.

The organization of the thesis is as follows. The next chapter is dedicated to a summary of previous studies that aim to model the productivity in the presence of pollutants and the survey of literature on the topics investigated. Chapter 3 is reserved for the methodology that is used in constructing indices employed in this study. The next chapter provides the information on the data used and the application of this panel data to construct environmental performance and productivity indices. This chapter also dedicated to the comparison of Malmquist and Malmquist-Luenberger productivity indices. Finally chapter 5 concludes.

CHAPTER 2

SURVEY OF THE LITERATURE

The following sub sections summarize the existing literature on the productivity indices that are used in this study as well as the environmental efficiency indices.

2.1. Malmquist Productivity Index

By using the data on outputs and inputs, the methodology of Malmquist productivity index relies on constructing a best practice frontier and then computing the distance of individual observations from the frontier constructed over the whole sample. In contrast to the alternative indices such as Törnquist and Fischer that require information on both the prices and quantities of all inputs and outputs, this index requires information only on quantities.

By following Stan Malmquist's (1953) quantity index, Caves et al. (1982a, 1982b) introduced two theoretical indices which they named Malmquist input and output productivity indices. In their pioneering study, they compare two input-output vectors to a reference technology using radial input and output scaling, for the input and output productivity indices respectively. Although their paper was influential, the Malmquist productivity index itself was rarely computed until Fare et al. (1989b) showed how this index could be calculated using non-parametric linear programming method. In their study they also showed that Malmquist productivity index could be decomposed into technological progress and technical efficiency components. Later, Ray and Desli (1995) decomposed the Malmquist productivity index into three components namely technical change, scale efficiency change and efficiency change.

Following these pioneering theoretical studies, great number of empirical literature has emerged. The application of Malmquist productivity index includes public sectors, agriculture, transportation, banking, electric utilities, insurance companies and the country comparisons of productivity. Since there are literally over 200 empirical papers on Mamquist productivity index, we here cite only the path breaking and significant ones.

The first application of the Malmquist productivity index on public sector was Fare et al. (1994b). They compute the index and decompose into technical and efficiency change components for the Swedish hospital sector for the time period 1970 to 1985. Their results indicate a considerable variation in efficiency change among 17 hospitals in their sample and the technical change component showed both progress and regress. Later, Burgess and Wilson (1995) and Magnussen (1994) applied the same methodology to U.S and Norwegian hospital ownership respectively. The application of this index on Turkey's public enterprise sector was Taskin and Zaim (1995). Their results showed that the growth in the public sector was 14% on average and 37% for the private sector. The major reason for the growth is technical change while there has been a decline in the efficiency component.

The first study that applied the Malmquist productivity index to agricultural sector was Thirtle, Hadley and Townsend (1994). They computed the input-based Malmquist indices for agriculture in sub-Saharan countries for the period 1971-1986. They assumed that land, labor and livestock are used to produce aggregate agricultural output. They found that productivity growth is small but generally positive. To cite, other major empirical studies that employed this methodology on agricultural sector was Tauer(1994), Turk, Piesse and Thirtle (1996) and Ferrantino and Ferrier (1996). Tauer (1994) measured the productivity of New York dairy farms. Turk, Piesse and Thirtle (1996) assessed the performance of co-operative and private dairy farms of Slovenia from 1974 to 1990. Ferranino and Ferrier (1996) used the Malmquist index to measure the performance of Indian sugar industry.

Transportation is another industry that the Malmquist productivity index has been used. The significant examples are Starr McMullen and Okuyama (1996), Good and Sickles (1995) and Distexhe and Perelman (1995). Starr McMullen and Okuyama (1996) computed the Malmquist productivity index for U.S motor carriers over the period 1976 and 1990. They found significant technological regress occurring in 1976-1978, 1979-1981 and 1987-1989. Good and Sickles (1995) applied the same methodology to Western European airline carriers. Distexhe and Perelman (1995) measured the productivity among the international airlines.

Employing Malmquist productivity index on banking and financial sector is quite popular. Most of the works analyze the performance of banks within one country and a few make international comparisons. The first significant example was Berg, Forsund and Jansen (1992). They compute the productivity change for Norwegian banks during 1980's when the banking industry was deregulated. Their results suggest regress in the earlier years and progress in the later years of sample on average. Other significant empirical works include Tulkens and Malnero (1996), Fukuyama (1995a), Wheelock and Wilson (1994) and Devaney and Weber (1995). Tulkens and Malnero (1996) analyzed the productivity of 663 branches of one bank in Belgium over 11 month period in 1987. Fukuyama (1995) computed the Malmquist productivity index for Japanese banks over the period 1989 to 1991. Wheelock and Wilson (1994) use the Malmquist index to measure productivity of U.S commercial banks from 1984 to 1993. Devaney and Weber (1995) analyzed the productivity for all U.S rural banks for 1990, 1992 and 1993.

Hjalmarsson and Veiderpass (1992) and Forsund and Kittlsen (1994) are two significant examples of empirical work that employed Malmquist productivity index on electric utility industry. Hjalmarsson and Viedepass (1992) used Malmquist index to measure the productivity of 289 Swedish electricity retail distributors during the period from 1970 to 1986. Forsund and Kittelsen (1994) assess the Norwegian electricity distribution system by the data from 1983 and 1989.

The first study that measures the productivity in a insurance sector was Donni and Fecher (1995). They assess and compare the productivity of insurance sectors of 15 OECD countries from 1983 to 1991. Other significant empirical work includes Fukuyama (1995b) and Cummins, Turchetti and Weiss (1995). Fukuyama (1995b) computed the productivity of Japanese life insurance companies over the time period 1988-1993. He concluded that productivity improved during the time period considered mainly due to technical change. Cummins, Turchetti and Weiss (1995) employed the Malmquist productivity index for 94 insurance companies in Italy for the time period 1985-1993.

Perelman (1995), Taskin and Zaim (1995) and Gouyette and Perelman (1995) are the significant empirical works that employ the Malmquist productivity index in country comparison studies. Perelman (1995) provides an international comparison for a sample of OECD countries for the time period 1970-1987. Taskin and Zaim (1996) compute the Malmquist productivity index for a sample of high and low income countries over the 1975-1990 period. They concluded that the countries with low initial per capita income catch up at a faster rate while countries with relatively high per capita income depend more on technological progress for their productivity increases. Gouyette and Perelman (1995) compute the Malmquist indices for a sample of 13 OECD countries for different sub sectors over the 1970-1988 period.

Although Malmquist productivity index has many desirable properties and applications on different sectors, one should modify this index to assess the productivity in the presence of the joint production of desirable and undesirable outputs.

2.2. Malmquist-Luenberger Productivity Index

This index is actually a modified version of Malmquist index and first presented in Chung et al. (1997). They substitute directional distance functions for the output distance functions in the Malmquist index and rename it the Malmquist-Luenberger productivity index. The new index they proposed in this study overcomes the shortcomings of the original Malmquist productivity index. This index allows for the inclusion of undesirable outputs (pollutants) in the measurement of productivity without requiring information on shadow prices. Since the index is computed using a DEA methodology, information concerning benchmark samples and technical efficiency is also generated for individual observations. In order to illustrate the applicability of this index, they compute the productivity for the Swedish paper and pulp industry. This index again can be decomposed into efficiency change and technological change parts.

Since the literature on this index is very new, there are considerably few studies available that employ this index in the measurement of productivity. One of the significant examples was Fare et al. (2001). They used a Malmquist-Luenberger productivity index to account for both marketed outputs and the output of pollution abatement activities of U.S state manufacturing sectors for 1974-1983. They found that adjusted productivity growth improved for the sample states after 1977, and the states with rapidly growing manufacturing sectors have significantly higher rates of productivity growth than the states with slowly growing manufacturing sectors.

Another study that incorporates the pollutants into the production technology for state manufacturing industries explicitly was Weber and Domazlicky (2001). They apply the Malmquist-Luenberger productivity index to state manufacturing data and the aggregated emissions for 1988-1994. The productivity index that only considers the desirable output and ignores the output of the pollution abatement activities of the manufacturing sector yields a decline in the annual productivity. However, when the productivity index includes both the expansion of the desirable output and the contraction of the undesirable output (pollutant) they find an increase in the state manufacturing productivity.

Malmquist-Luenberger productivity index is certainly an improvement over the traditional measures of productivity growth and Ma1mquist productivity index. However, this index still fails to establish a link between pollution intensities and productivity growth since it does not allow us to make cross-country and over time comparisons over developments in pollution intensities i.e., bad over good ratios. Within this framework, alternative indices by index number theory and environmental efficiency indices are developed to measure the environmental performance.

2.3. Environmental Efficiency Index and Alternative Indices

The literature on the environmental efficiency indices depends on the literature of `production frontiers` and `Farrell measure of technical efficiency`, which starts with Farrell (1957) and later extensively covered in Shephard (1970), Fare et al. (1985b), (1994a) and Fried et al. (1993). On measuring environmental performance and constructing the efficiency indices, one of the two methodologies are employed. These are stochastic frontier estimation and data envelopment analysis (DEA). Both approaches are quite favorable. For example, Reinhard et al. (1996) used a stochastic frontier approach to construct an environmental efficiency index with micro level data while Ball et al. (1994) and Tyteca (1997) adapted the DEA methodology to measure environmental performance. Later Reinhard (1997) used both approaches to show the pros and cons of two methods.

There are alternative approaches according to the selection of the type of the efficiency measure in the studies that DEA framework is employed. Fare et al. (1986) and (1989c) used radial measures of technical efficiency to compute the desirable output loss, which stems from the reduced disposability of the undesirable outputs. Another example of using radial measure was Fare et al. (1996). They rely on the comparison of two input (output) oriented radial technical efficiency scores, one accounts for the production of environmentally undesirable outputs and the other which completely ignores the production of pollutants with desirable outputs.

As opposed to radial measure, the alternative efficiency measure is hyperbolic measure of technical efficiency. In their path breaking study Fare et al. (1989a), suggested this methodology. This measure of technical efficiency allows for simultaneous equiproportionate reduction in the undesirable outputs (bads) with an expansion of desirable outputs (goods). The importance of this measure is to compute the opportunity cost of transforming the production process from one where all outputs are strongly disposable to the one, which is characterized by weak disposability of undesirable outputs. Later hyperbolic measure of technical efficiency is employed in constructing environmental efficiency indices in the works of Zaim and Taskin (1999), Zaim and Taskin (2000) and Taskin and Zaim (2000). They employed this measure and environmental efficiency indices to measure the environmental performance of OECD countries and search for a Kuznets curve relationship in environmental efficiency.

On the other hand alternative indices are also quite popular in measuring the environmental performance. These indices are very much like the Malmquist Index, but rather than scaling the full output vector, they scale the desirable and undesirable outputs separately. These indices are first developed in Zaim et al. (2001) and used in the measurement of human well-being. They propose two indices in this study, which they called achievement (quantity index) and improvement indices. The general methodology again depends on micro tools in index number theory, Farrell efficiency measures and DEA methodology. One very significant property of their indices was that they allow for cross country and overtime comparisons. It also satisfies some desirable properties such as transitivity, time reversal, homogeneity and dimensionality. These desirable properties in index numbers theory were first presented in Fischer (1922). For a detailed discussion of theoretical underpinnings of various index numbers one can refer to Diewert (1979).

Fare et al. (2002) also developed this methodology and later on, Grosskopf et al. (2003) used the same methodology on measuring how efficiently public health expenditures are translated into better health. The application of this methodology to environmental data is again Zaim (2002). Basically his index is defined as the ratio of a good output quantity index and a quantity index of bad or undesirable outputs. Each of the two indices is based on distance functions and DEA methodology is employed. This study measured the environmental performance of state manufacturing through changes in pollution intensities.

The studies on measuring productivity in the presence of pollutants and constructing indices to measure environmental performance also effort to relate and search for an environmental Kuznets curve hypothesis, which assumes an inverted U-type relationship between the levels of emissions and income. For further discussion of this issue see Grossman and Kruger (1993), Cropper and Griffith (1994), Selden and Song (1994), Holtz-Eakin and Selden (1995) and Taskin and Zaim (2000).

CHAPTER 3

METHODOLOGY

This chapter of the thesis presents the basic methodology underlying the indices that are used to measure the productivity in the presence of pollutants as one of the outputs in production process. The indices taken into consideration are Malmquist productivity index and Malmquist-Luenberger productivity index. To measure the environmental performance, an alternative index is also presented which employs the index number approach and DEA methodology using a non-parametric approach. A series of papers such as Fare et al. (1989b), Chung et al. (1997) and Fare et al. (1999) are followed for the methodology presented in the proceeding sections.

3.1. Distance Functions and Joint Production of Goods and Bads

Mainly, in a production process for a given inputs, good (desirable) and bad (undesirable or pollutants) outputs are produced. Formally, denote the good outputs by $y = (y_1, ..., y_M) \in R_+^M$ and the bad outputs by $b = (b_1, ..., b_I) \in R_+^I$. Therefore, the output set (y, b) is produced by the input set $x = (x_1, ..., x_N) \in R_+^N$. Then, technology can be described via its output set:

(3.1.1) $$T = \{(x, y) : x \text{ can produce } (y, b)\}$$

In words, for each input vector $x = (x_1,...,x_N) \in R_+^N$, the technology set includes all the combinations of good and bad outputs or the output set (y,b), which can be produced by the vector of inputs.

Technology set is also equivalent to output set $P(x)$ or may be represented by the input set $L(y,b)$ such that:

(3.1.2) $$(x,y,b) \in T \Leftrightarrow (y,b) \in P(x) \Leftrightarrow x \in L(y,b)$$

The weak disposability assumption of output set (y,b) can be modeled as:

(3.1.3) $$(y,b) \in P(x) \text{ and } 0 \le \theta \le 1 \text{ imply } (\theta y, \theta b) \in P(x)$$

In words, this assumption implies that given a fixed level of inputs, a reduction in bads is feasible only when the goods are also simultaneously reduced. However, free disposability of good outputs is still maintained. That is good outputs may be reduced without the reduction of the bad outputs. In notation:

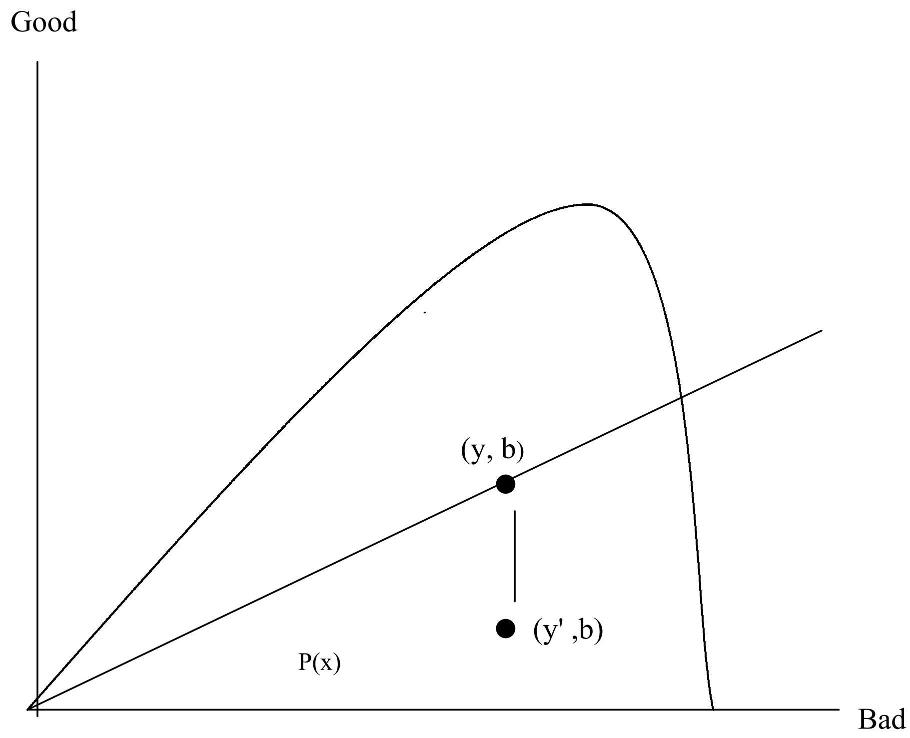
(3.1.4) $$(y,b) \in P(x) \text{ and } y' \le y \text{ imply } (y',b) \in P(x)$$

Equations (3.1.3) and (3.1.4) together model the asymmetry between the good and bad outputs where goods are freely disposable while the bads are not. The last assumption is null-jointness, which says that no desirable outputs can be produced without producing any bad outputs. This idea of joint production of good and bad outputs can be modeled as:

(3.1.5) $$if\ (y,b) \in P(x) \text{ and } b = 0 \text{ then } y = 0$$

In figure 3.1.1, we illustrate an example of such a joint output set that satisfies these properties.

Figure 3.1.1. An Output Set



In addition to the assumptions on the joint production of good and bad outputs, we may also impose some restrictions over the output set $P(x)$. To model the idea that zero inputs yields zero outputs we have:

(3.1.6) $$P(0) = \{0,0\}$$

On the other hand, we may also assume that given finite inputs, only finite output can be produced. This is in notation:

(3.1.7) $P(x)$ is compact for each $x \in R_+^N$

The final assumption on output set $P(x)$ is:

(3.1.8) $$P(x) \supseteq P(x^{'}), x \geq x^{'}$$

This assumption imposes free disposability of inputs, which essentially implies that if inputs are increased then output does not decrease.

Fallowing Fare et al. (1994a), we may formulate the activity analysis or data envelopment analysis (DEA). We assume that there are K observations on inputs and outputs, where k indexes each individual observation such that $\{(x^k, y^k, b^k): k = 1,...,K\}$. By this data we can construct an output set that holds for every period and satisfies our previous assumptions. Formally:

$$
\begin{aligned}
P(x) = \{(y,b): \quad & \sum_{k=1}^{K} z_k y_{km} \geq y_m, \quad && m = 1,...,M, \\
& \sum_{k=1}^{K} z_k b_{ki} = b_i, && i = 1,...,I, \\
& \sum_{k=1}^{K} z_k x_{kn} \leq x_n, && n = 1,...,N, \\
& \mathrm{z_k} \geq 0, && k = 1,...,K\},
\end{aligned}
\tag{3.1.9}
$$

where the non-negative $\mathrm{z_k}$ are the intensity variables (weights) assigned to each observation when constructing the production set. The inequality constraint on the good output $y = (y_1,...,y_M) \in R_+^M$ in (3.1.9) states the assumption of free disposability, which means that the desirable output can be disposed of without the use of any inputs. If we also consider the production of bad output $b = (b_1,...,b_I) \in R_+^I$ together with the desirable output, we should impose the weak disposability condition that satisfies the assumption we introduced in (3.1.3) by choosing an equality sign for the relevant constraint. To satisfy the null-jointness introduced before, we restrict the conditions:

$$
\sum_{k=1}^{K} b_{ki} > 0, \; i = 1,...,I, \tag{3.1.10}
$$

and

(3.1.11) $$\sum_{i=1}^{I} b_{ki} > 0,\ i = 1,...,K\ .$$

The inequality (3.1.10) states that each undesirable or bad output is produced by some individual sample *k* (firm or county). On the other hand, (3.1.11) implies every *k* produces at least one bad output. We may further illustrate null-jointness by assuming that each $b_i = 0$, where $i = 1,..., I$. Then each intensity variable z_k in (3.1.9) will be zero, implying that all the desirable good outputs y_m must be zero. Therefore, these two restrictions can be used to determine whether a particular data set satisfies null-jointness of desirable and undesirable outputs. To impose this assumption our application will not include the data that violate the null-jointness.

Further, the non-negativity of intensity variables in (3.1.9) implies that the production technology exhibits constants returns to scale. That is:

(3.1.12) $$P(\lambda x) = \lambda P(x), \lambda > 0.$$

3.2. Malmquist Productivity Index

In this section, we present the Malmquist productivity index without considering the joint production of goods and bads. Since our whole analysis depends on the assumption that we have no information on prices, distance functions are our proxies for defining and measuring productivity. The original Malmquist productivity index uses Shephard distance functions to represent the underlying technology (Shephard, 1970). In the presence of only goods (desirable outputs), these output distance functions can be defined as:

(3.2.1) $$D_o(x, y) = \inf\{\theta : (x, \frac{y}{\theta}) \in P(x)\}$$

This output distance function is complete characterization of technology. For each observation, the output distance functions can be computed by solving the following linear problem for k`:

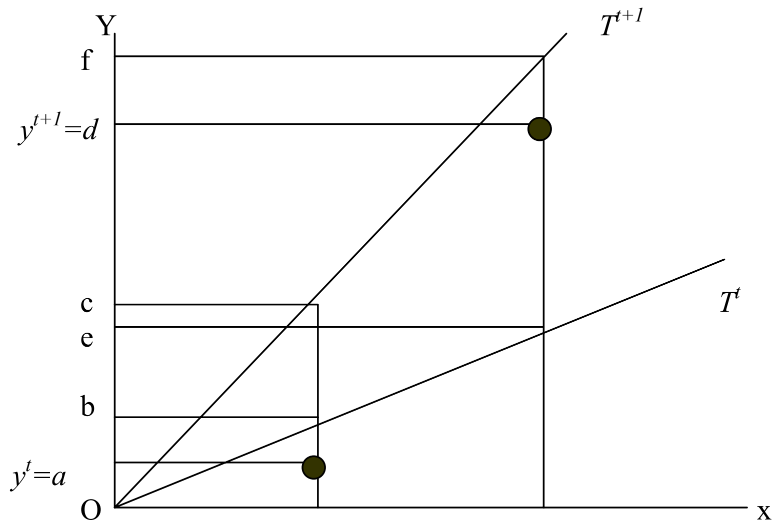
(3.2.2)
$$\begin{aligned}
&(D_o^t(x^{t,k'}, y^{t,k'}))^{-1} = \max\theta \\
&st \\
&\sum_{k=1}^{K} z_k y_{km}^t \geq \theta y^t{}_{k'm} \qquad m = 1,\ldots.,M \\
&\sum_{k=1}^{K} z_k x_{kn}^t \leq \mathrm{x}_{k'n}^t \qquad n = 1,\ldots.,N \\
&z_k \geq 0 \qquad k = 1,\ldots\ldots,K
\end{aligned}$$

Taking *t = 1,…, T* as our time periods, we can define an output oriented Malmquist productivity index that does not incorporate the bad outputs by fallowing Fare et al. (1989b) such that:

(3.2.3)
$$M_o(x^t, y^t, x^{t+1}, y^{t+1}) = \left[\frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)} \frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^t, y^t)}\right]^{1/2}$$

We may illustrate the output-oriented Malmquist productivity index in a figure. In figure 3.2.1, two technologies are involved, one for period t and the other for period $t+1$.

Figure 3.2.1. Output-Oriented Malmquist Productivity Index



The productivity change for the two input-output vectors (x^t, y^t) and (x^{t+1}, y^{t+1}) based on y-distances is:

(3.2.4) $$M_o(x^t, y^t, x^{t+1}, y^{t+1}) = \left[\frac{Od}{Oe}\frac{Ob}{Oa}\frac{Oc}{Oa}\frac{Od}{Of}\right]^{1/2}$$

Malmquist productivity index can also be decomposed into efficiency change (MEFFCH) and technical change (MTECH) components. These two components can be defined as:

(3.2.5) $$MEFFCH = \frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)}$$

and

(3.2.6) $$MTECH = \left[\frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^{t+1}, y^{t+1})}\frac{D_o^t(x^t, y^t)}{D_o^{t+1}(x^t, y^t)}\right]^{1/2}$$

The Malmquist productivity index is simply the product of these two components, namely:

(3.2.7) $$M_t^{t+1} = MEFFCH_t^{t+1} \cdot MTECH_t^{t+1}.$$

In figure 3.2.1, efficiency change and technical change components can be defined as:

(3.2.8) $$MEFFCH = \frac{Od}{Of}\frac{Ob}{Oa}$$

and

(3.2.9) $$MTECH = \left[\frac{Of}{Oe}\frac{Oc}{Ob}\right]^{1/2}$$

This index has several desirable features such that as opposed to alternative indices like Fischer and Törnquist, it does not require any price information on outputs and inputs. However, although in principle Malmquist productivity index can be used to measure the productivity in the presence of bads, the underlying distance functions does not allow us to credit our individual observations for reductions in pollutants. If we try to incorporate the bads into productivity by employing Malmquist productivity index, the output distance functions can be represented as:

(3.2.10) $$D_o(x, y, b) = \inf\{\theta : ((y, b/\theta)) \in P(x)\}$$

However, the output distance function in (3.2.10) without crediting the reduction of bads, expands the desirable and undesirable output set *(y, b)* proportionally as much as it is feasible. This is the major deficiency of this index when we consider the joint production of goods and bads. Further discussion of this point can be seen in Chung et al. (1997).

3.3. Malmquist-Luenberger Productivity Index

This modified version of original Malmquist productivity index is first developed in Chung et al. (1997) and to represent technology, rather than using Shephard output distance functions, employs directional output distance functions. This approach credits the firms or countries for the reduction of undesirable outputs by seeking to increase the good outputs while simultaneously decreasing the bads. We may formulate the directional distance functions as:

(3.3.1) $$\vec{D}_o(x, y, b; g) = \sup\{\beta : (y, b) + \beta g \in P(x)\}$$

where g is the vector of directions which is defined as g = *(y, -b)*. It is also possible to construct a relation between Shephard and directional distance functions. By 3.3.1, by letting g = (y, b) we may write:

(3.3.2)
$$\begin{aligned}
&\vec{D}_o(x, y, b; y, b) = \sup\{\beta : D_o(x, (y, b) + \beta(y, b)) \leq 1\} \\
&= \sup\{\beta : (1+\beta) D_o(x, y, b) \leq 1\} \\
&= \sup\{\beta : \beta \leq \frac{1}{D_o(x, y, b)} - 1\} \\
&= \frac{1}{D_o(x, y, b)} - 1
\end{aligned}$$

and therefore:

(3.3.3) $$\vec{D}_o(x, y, b; y, b) = (1 / D_o(x, y, b)) - 1$$

or equivalently

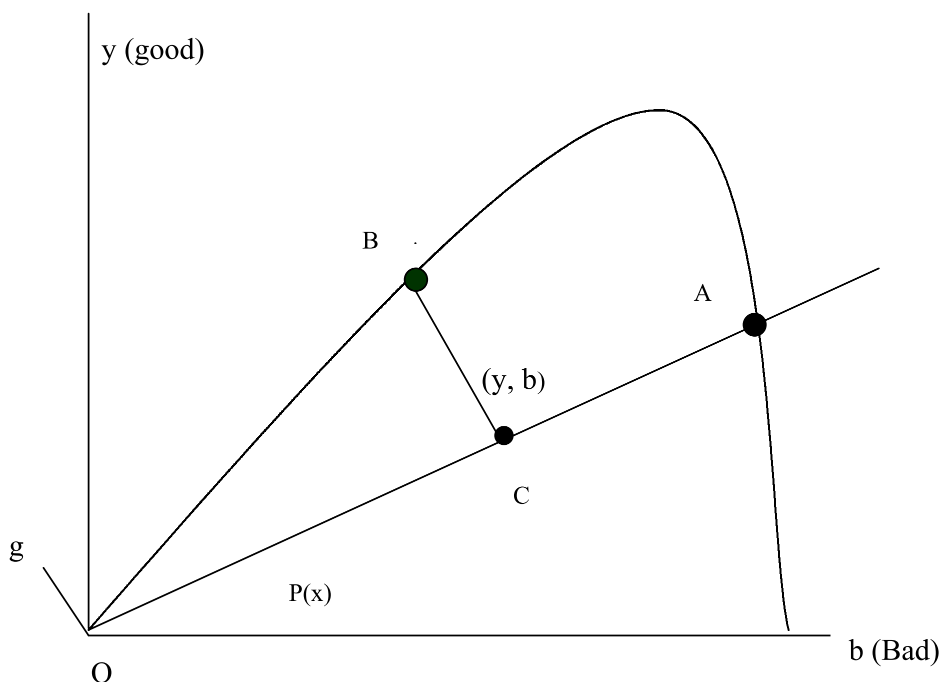
(3.3.4) $$D_o(x, y, b)) = 1/(1 + \vec{D}_o(x, y, b; y, b))$$

Similar to Shephard distance functions, directional distance functions can also be computed as a solution to linear programming problems. We can formalize such a problem for $k`$:

$$(3.3.5)\qquad \begin{aligned} &(\vec{D}_o^t(x^{t,k'}, y^{t,k'}, b^{t,k'}; y^{t,k'}, -b^{t,k'}) = \max \beta \\ &st \\ &\sum_{k=1}^{K} z_k y_{k'm}^t \geq (1+\beta) y^t{}_{k'm} \qquad m = 1,....,M \\ &\sum_{k=1}^{K} z_k b_{ki}^t = (1-\beta) b_{k'i}^t \qquad i = 1,....,I \\ &\sum_{k=1}^{K} z_k x_{kn}^t \leq (1-\beta) \mathrm{x}_{k'n}^t \qquad n = 1,....,N \\ &z_k \geq 0 \qquad k = 1,......,K \end{aligned}$$

To make a more precise distinction between the directional and Shephard type distance functions, we may refer to figure 3.3.1.

Figure 3.3.1. Distance Functions



In Figure 3.3.1, the output set is defined by *P(x)*. As already introduced, this output set is defined by goods (y) and bads (b) on the y- and x-axis respectively. We may refer to the Shephard distance functions by the value OC/OA. If the firm or country increases both goods and bads by this value, then it is judged as efficient. In contrast, for directional distance functions, we should refer the ratio BC/Og. That is, the directional distance function starts at C and scales in the direction of increased goods and decreased bads and projects C on the boundary at B. Then the firm or country is called efficient if it moved from C to B. This actually implies a reduction in bads and an increase in goods.

After making this distinction between the directional and Shephard distance functions, we may follow Chung et al. (1997) to write the Malmquist-Luenberger productivity index. By letting *g = (y, -b)*, the output-oriented Malmquist Luenberger productivity index is:

(3.3.6)

$$ML_t^{t+1} = \left[\frac{(1+\vec{D}_o^t(x^t, y^t, b^t, -b^t))}{(1+\vec{D}_o^t(x^{t+1}, y^{t+1}, b^{t+1}; y^{t+1}, -b^{t+1}))} \frac{(1+\vec{D}_o^{t+1}(x^t, y^t, b^t; y^t, -b^t))}{(1+\vec{D}_o^{t+1}(x^{t+1}, y^{t+1}, b^{t+1}; y^{t+1}, -b^{t+1}))} \right]^{1/2}$$

Note that if the direction function g = (y, b), this index coincides with the original Malmquist index. As all Malmquist type indices, this index can also be decomposed into efficiency change and technical change components. The efficiency component is:

(3.3.7) $$MLEFFCH_t^{t+1} = \frac{1+\vec{D}_o^t(x^t, y^t, b^t, -b^t)}{1+\vec{D}_o^{t+1}(x^{t+1}, y^{t+1}, b^{t+1}; y^{t+1}, -b^{t+1})}$$

and the technical change component can be written as:

(3.3.8)

$$MLTECH_t^{t+1} = \left[\frac{(1+\vec{D}_o^{t+1}(x^t, y^t, b^t, -b^t))}{(1+\vec{D}_o^t(x^t, y^t, b^t, -b^t))} \frac{(1+\vec{D}_o^{t+1}(x^{t+1}, y^{t+1}, b^{t+1}; y^{t+1}, -b^{t+1}))}{(1+\vec{D}_o^t(x^{t+1}, y^{t+1}, b^{t+1}; y^{t+1}, -b^{t+1}))} \right]^{1/2}$$

and as in the Malmquist index the product of these two components gives the Malmquist-Luenberger Index.

(3.3.9) $$ML_t^{t+1} = MLEFFCH_t^{t+1} \cdot MLTECH_t^{t+1}.$$

3.4. Index Number Approach

In this section, an environmental performance index developed in Fare et al. (1999) is adopted. Basically the index they defined is the ratio of two indices namely good output quantity index and bad output quantity index. These indices are developed using a DEA framework and distance functions like Malmquist index. However in contrast to Malmquist index, this index employs sub-vector distance functions since it scales the good and bad outputs separately. It also satisfies the properties of closedness and convexity due to Fare and Primont (1995). We may formally define a sub-vector distance functions for good outputs as:

(3.4.1) $$D_y(x, y, b) = \inf\{\theta : (x, y/\theta, b) \in T\}$$

This distance function holds the inputs and bad outputs fixed and expands the good outputs as much as is feasible. Note that it is also homogeneous of degree +1 in y. Keeping the notation used, let x^0 and b^0 be our given inputs and bad outputs, then the good output index compares two output vectors y^k and y^l by taking the ratio of two distance functions. Then, the good index is:

(3.4.2) $$Q_y(x^0, b^0, y^k, y^l) = \frac{D_y(x^0, y^k, b^0)}{D_y(x^0, y^l, b^0)}.$$

On the other hand, the index of bad outputs is constructed using an input distance function approach. The input based distance function for bad outputs can be written as

(3.4.3) $$D_b(x, y, b) = \sup\{\lambda : (x, y, b/\lambda) \in T\}.$$

This distance function is homogeneous of degree +1 in bad outputs, and it is defined by finding the maximal contraction in these outputs. Given (x^0, y^0), the quantity index of bad outputs compares b^k and b^l and can be defined using the ratios of distance functions such that:

(3.4.4) $$Q_b(x^0, y^0, b^k, b^l) = \frac{D_b(x^0, y^0, b^k)}{D_b(x^0, y^0, b^l)}.$$

The bad index defined in (3.4.4) with the good index defined in 3.4.2 satisfies some desirable index number properties due to Fischer (1922). These desirable properties for bad index are:

(3.4.5) Homogeneity: $Q_b(x^0, y^0, \lambda b^k, b^l) = \lambda Q_b(x^0, y^0, b^k, b^l)$

(3.4.6) Time-reversal: $Q_b(x^0, y^0, b^k, b^l) Q_b(x^0, y^0, b^k, b^l) = 1$

(3.4.7) Transitivity: $Q_b(x^0, y^0, b^k, b^l) Q_b(x^0, y^0, b^k, b^l) = Q_b(x^0, y^0, b^k, b^l)$

(3.4.8) Dimensionality: $Q_b(x^0, y^0, \lambda b^k, \lambda b^l) = Q_b(x^0, y^0, b^k, b^l)$

The environmental performance index of Fare et al. (1999) is the ratio of good and bad indices, i.e.:

$$(3.4.9) \qquad E^{k.l}(x^0, y^0, b^0, y^k, y^l, b^k, b^l) = \frac{Q_y(x^0, b^0, y^k, y^l)}{Q_b(x^0, y^0, b^k, b^l)}$$

This performance index allows us to evaluate how much good output is produced per bad output. If we consider a simple case where there is only one good and one bad output is produced, this index can be written in the following form due to homogeneity of the component distance functions.

$$(3.4.10) \qquad E^{k.l} = \frac{y^k / b^k}{y^l / b^l}$$

This one bad one good index states that the index is the ratio of average good per bad output for k and l.

CHAPTER 4

DATA, APPLICATION AND COMPARISON

This chapter first presents the data used in this thesis. Then, the following sub sections summarize the application of the data and comparison of our Malmquist and Malmquist-Luenberger indices. Final section is reserved for the application of environmental efficiency index.

4.1. The Data

Basically, in a production process for a given inputs, good (desirable) and bad (undesirable or hazardous) outputs are produced. Our resource constraint (inputs) in constructing the Malmquist and Malmquist-Luenberger Productivity indices and environmental performance index are represented by net fixed standardized capital stock and labor (number of employed workers). As a good (desirable) output, GDP, purchasing power parity (PPP) adjusted with 1996 prices is used. Our proxies for hazardous outputs are industrial CO_2 (carbon dioxide) and NO_x (nitrogen oxide) emissions and organic water pollutant emissions.

The data on capital stock, labor and GDP are compiled from a recent data set (Marquetti, 2002). World Development Indicators (World Bank, 2002) are used for CO_2 and organic water emissions whereas NO_x emissions are compiled from World Marketing Database (Euromonitor, 2002).

Our annual data set includes 28 OECD countries. Slovak Republic and Czech Republic are excluded because of the unavailability of the data for these countries. The time period considered is 16 years, 1983 to1998. In table 4.1.1 we present the data as the average of 16 years for each of the OECD countries.

Table 4.1.1. The Data as the Average of the Period 1983-1998

Country Code	Capital Stock	Labor	GDP	CO2	Water Pollutant	NOX
AUS	605	8208	347	257	176	2188
AUT	290	3652	149	55	88	194
BEL	316	4154	199	99	115	342
CAN	1061	14042	609	412	306	2027
DNK	200	2819	113	56	80	272
FIN	209	2503	93	50	74	277
FRA	2043	25634	1095	354	633	1636
GER	3068	39725	1555	865	836	2585
GRC	213	4001	123	70	61	342
HUN	144	4733	96	66	165	225
ISL	9	137	5	2	7	21
IRL	81	1365	50	31	34	113
ITA	1810	22799	1055	385	368	1803
JPN	6015	77829	2578	1044	1502	1398
KOR	970	17795	448	269	347	1023
LUX	16	166	11	9	7	13
MEX	922	28474	637	305	160	1522
NLD	480	6504	288	133	134	548
NZL	103	1585	91	24	49	151
NOR	231	2124	95	65	54	214
POL	378	18456	254	382	426	1248
PRT	180	4457	118	40	123	293
ESP	878	14563	524	207	324	1090
SWE	269	4431	171	53	105	361
CHE	341	3569	169	41	135	156
TUR	434	24316	344	143	170	677
GBR	1436	28398	1036	553	702	2362
USA	8591	126054	6707	4863	2538	21391
AVERAGE	1118	17589	677	387	347	1588

Capital Sock: Estimated Net Fixed Standardized Capital Stock (billion $)
Labor: Number of Workers ('000 workers)
GDP: Gross Domestic Product (1996, PPP) (billion $)
CO2: Carbon Dioxide Emissions, Industrial ('000 kt)
Water Pollutant: Organic Water Pollutant (BOD) Emissions ('000 kg per day)
NOX: Nitrogen Oxide Emissions (' 000 kt)

Note that, carbon dioxide and nitrogen oxide emissions from industrial processes are those stemming from the burning of fossil fuels and the manufacture of cement. They include contributions to the carbon dioxide and nitrogen oxide produced during consumption of solid, liquid, and gas fuels and gas flaring. On the other hand, Emissions of organic water pollutants are measured by biochemical oxygen demand, which refers to the amount of oxygen that bacteria in water will consume in breaking down waste. This is a standard water-treatment test for the presence of organic pollutants.

4.2. Malmquist and Malmquist-Luenberger Indices, Application

We begin our analysis by computing the Malmquist productivity index including only good outputs. In table 4.2.1, we report the Malmquist productivity index and its decomposition into technical and efficiency change for the time period 1985 to 1998 by sequential multiplication of the improvements in each sub-period. Recall that values greater than unity indicate an improvement in productivity performance, while values less than unity implies deterioration. Remarkably, all OECD countries improved their productivity during the time span considered except Canada, Japan, Korea, New Zealand, Portugal, Switzerland, and Great Britain. Clearly, Ireland, Luxembourg and Finland are best performers and generate substantial productivity growth. Moreover, the results suggest that technical change dominates efficiency change as a source of productivity growth. We may also say that OECD countries improved their productivity approximately %3 for the 1985-1998 period. For a detailed exposition, in appendix B, tables 4.2.3, 4.2.4 and 4.2.5 presents the Malmquist productivity index and its decomposition into technical and efficiency change respectively for all OECD countries and each sub period considered.

Table 4.2.1. Malmquist Productivity Index and Decomposition: 1985-1998

Country Code	Malmquist Index	Technical Change	Efficiency Change	Rank
AUS	1,0792	1,1296	0,9555	14
AUT	1,0767	1,1362	0,9477	15
BEL	1,0030	1,0673	0,9398	22
CAN	0,9632	1,0822	0,8901	23
DNK	1,0741	1,1026	0,9745	16
FIN	1,4701	1,3460	1,0925	3
FRA	1,1124	1,1442	0,9722	11
GER	1,1174	1,1466	0,9747	10
GRC	1,2583	0,9900	1,2713	6
HUN	1,0574	1,0158	1,0412	17
ISL	1,1905	1,0990	1,0833	7
IRL	1,6419	0,9890	1,6604	1
ITA	1,1110	1,1563	0,9610	12
JPN	0,9221	1,0061	0,9166	27
KOR	0,7514	0,9955	0,7546	29
LUX	1,4987	1,4987	1,0000	2
MEX	1,1715	1,0128	1,1568	8
NLD	1,1209	1,1584	0,9678	9
NZL	0,9535	0,9882	0,9651	25
NOR	1,2871	1,4898	0,8640	5
POL	1,4619	1,0416	1,4035	4
PRT	0,9366	1,0026	0,9340	26
ESP	1,0099	0,9871	1,0231	21
SWE	1,0797	0,9855	1,0956	13
CHE	0,8850	1,4007	0,6318	28
TUR	1,0133	1,0509	0,9645	20
GBR	0,9558	0,9921	0,9634	24
USA	1,0251	1,0303	0,9948	19
GEOMEAN	1,0288	1,0579	0,9727	18

In constructing our Malmquist-Luenberger productivity index, we assume the joint production of goods and bads. This approach credits the countries for reduction of undesirable outputs by seeking to increase the good outputs while simultaneously decreasing the bads. Although our data set includes three undesirable outputs, we do not compute a Malmquist-Luenberger index that simultaneously decreases all three, since such an attempt creates too many infeasible solutions. Following Fare et al. (2001), in order to reduce the number of infeasible solutions, we further assumed that each year's technology is determined by observations on inputs and outputs of current and past two periods. Considering our pollutant data, we computed four different Malmquist-Luenberger productivity indices. These indices credit the reduction of only CO_2, NO_X and CO_2, NO_X and organic water pollutant and NO_X and water pollutant respectively. In table 4.2.2 we report the Malmquist-Lenberger productivity indices and their decompositions into efficiency and technical change for each of the OECD countries for the period 1985-1998. Although rankings of countries differ according to the pollutants included, Ireland and Norway are best performers in all indices. We also observe that technical change dominates efficiency change in all Malmquist-Luenberger productivity indices computed. Moreover, Poland and Luxembourg are the countries that all indices yield infeasible solutions for some years. All our indices indicate an approximately %8 productivity growth for OECD countries on average except the one which credits the reduction in NO_X and organic water pollutant. This index indicates a %19 productivity growth during the period 1985-1998.

Table 4.2.2. Malmquist-Luenberger Indices and Decompositions: 1985-1998

Bads	CO2				NOX / CO2			
	Index	Efficiency	Technical	Rank	Index	Efficiency	Technical	Rank
AUS	1,0629	0,9602	1,1070	19	0,9664	0,9988	0,9674	27
AUT	1,1266	1,0896	1,0338	10	1,1058	1,0972	1,0083	16
BEL	1,1171	1,0001	1,1169	15	1,1051	0,9618	1,1491	17
CAN	1,0275	0,9284	1,1068	23	1,0367	0,9542	1,0866	23
DNK	1,1273	1,0165	1,1091	9	1,2749	1,1532	1,1054	3
FIN	1,1876	1,1591	1,0245	3	1,1732	1,1737	0,9997	6
FRA	1,1765	1,1386	1,0333	4	1,1624	1,1162	1,0416	8
GER	1,1381	1,0624	1,0713	7	1,1858	1,1329	1,0469	4
GRC	1,1247	1,0367	1,0852	12	1,1281	1,0315	1,0935	12
HUN	1,1420	1,0611	1,0765	6	1,1402	1,0295	1,1078	10
ISL	1,1195	1,0052	1,1137	14	1,0417	0,9653	1,0790	22
IRL	1,4669	1,3202	1,1111	1	1,4397	1,2601	1,1424	2
ITA	1,1007	1,0366	1,0617	16	1,0945	1,0302	1,0624	19
JPN	0,9820	0,9860	0,9959	28	1,1762	1,0000	1,1762	5
KOR	0,9820	0,8716	1,1268	27	0,9200	0,8824	1,0428	29
LUX	1,0803	1,0000	1,0803	18	1,0972	1,0000	1,0972	18
MEX	1,1229	1,0183	1,1030	13	1,1185	1,0119	1,1058	13
NLD	1,1295	1,0180	1,1093	8	1,1552	1,0361	1,1148	9
NZL	0,9407	0,8611	1,0920	29	0,9422	0,8720	1,0805	28
NOR	1,4087	1,2022	1,1718	2	1,4606	1,2255	1,1919	1
POL	0,9996	0,9674	1,0334	25	0,9961	0,9682	1,0289	26
PRT	0,9879	0,8640	1,1434	26	1,0003	0,8805	1,1363	25
ESP	1,1249	0,9872	1,1392	11	1,1098	0,9621	1,1538	15
SWE	1,1673	1,0275	1,1360	5	1,1697	1,0262	1,1399	7
CHE	1,0133	1,0001	1,0133	24	1,1316	1,0000	1,1317	11
TUR	1,0578	0,9762	1,0836	21	1,0710	0,9795	1,0934	21
GBR	1,0559	0,9424	1,1204	22	1,1127	0,9699	1,1472	14
USA	1,0625	0,9985	1,0640	20	1,0292	1,0000	1,0291	24
GEOMEAN	1,0831	1,0050	1,0648	17	1,0943	1,0174	1,0762	20

Bads	NOX / WP				CO2 / WP			
	Index	Efficiency	Technical	Rank	Index	Efficiency	Technical	Rank
AUS	1,0324	1,0000	1,0324	23	1,1929	1,0312	1,1566	6
AUT	1,2851	1,0440	1,2311	4	1,1732	1,0586	1,1086	8
BEL	1,1073	0,8913	1,2424	19	1,1172	0,9912	1,1269	13
CAN	1,1587	0,9729	1,1910	14	1,0812	0,9528	1,1346	18
DNK	1,0676	0,9599	1,1123	21	1,1165	1,0250	1,0897	14
FIN	1,2806	1,0612	1,2066	5	1,2371	1,0925	1,1323	3
FRA	1,1847	0,9535	1,2424	13	1,2292	1,0874	1,1306	4
GER	1,2682	1,0699	1,1852	6	1,1391	1,0198	1,1173	11
GRC	1,1431	1,0000	1,1431	15	1,1436	1,0178	1,1240	10
HUN	0,8256	0,9611	0,8591	27	0,8788	0,9591	0,9162	29
ISL	0,6285	0,6451	0,9744	29	0,9426	0,9863	0,9557	27
IRL	1,4311	1,2269	1,1662	1	1,4477	1,2604	1,1483	2
ITA	1,1953	1,0000	1,1953	9	1,1738	1,0000	1,1738	7
JPN	1,1241	1,0000	1,1241	17	1,0573	0,9457	1,1186	21
KOR	1,1375	0,9732	1,1691	16	1,0360	0,9499	1,0908	23
LUX	1,1949	1,0000	1,1949	10	1,0236	1,0000	1,0236	24
MEX	1,3858	1,0000	1,3858	2	1,1512	0,9907	1,1619	9
NLD	1,2585	1,0163	1,2381	7	1,1374	1,0209	1,1143	12
NZL	1,0258	0,8980	1,1423	24	0,9258	0,8606	1,0758	28
NOR	1,3046	1,0228	1,2756	3	1,4494	1,1957	1,2122	1
POL	1,0097	0,9664	1,0447	26	1,0175	0,9674	1,0519	25
PRT	0,7908	0,7763	1,0186	28	1,0686	1,0000	1,0686	20
ESP	1,0727	0,8907	1,2044	20	1,1069	0,9505	1,1644	15
SWE	1,2180	1,0294	1,1832	8	1,2072	1,0038	1,2026	5
CHE	1,1120	1,0000	1,1120	18	1,0703	1,0000	1,0703	19
TUR	1,0454	0,9742	1,0731	22	1,1027	0,9859	1,1186	16
GBR	1,0180	0,9805	1,0383	25	1,0536	0,9355	1,1264	22
USA	1,1932	1,0000	1,1932	11	1,0084	1,0000	1,0084	26
GEOMEAN	1,1903	1,0036	1,1941	12	1,0848	0,9894	1,0963	17

For a detailed presentation, we report each of the Malmquist-Luenberger indices and their decompositions into technical and efficiency change for all countries and sub periods in appendix B, in tables 4.2.6 to 4.2.17. In each of the tables we also report the years in which infeasible solution for the individual countries occur.

4.3. Malmquist and Malmquist-Luenberger Indices, Comparison

Clearly, our Malmquist-Luenberger indices suggest a higher productivity growth for OECD countries. This result is expected since Malmquist productivity index does not account for the joint production of goods and bads while Malmquist-Luenberger index does. On the other hand, our Malmquist-Luenberger indices considerably differ according to the spearman correlations. This finding is consistent with our assumptions since we employ different pair of pollutants in the computation of these indices. The spearman correlations between Malmquist productivity index and Malmquist-Luenberger productivity indices are presented in table 4.3.1 below.

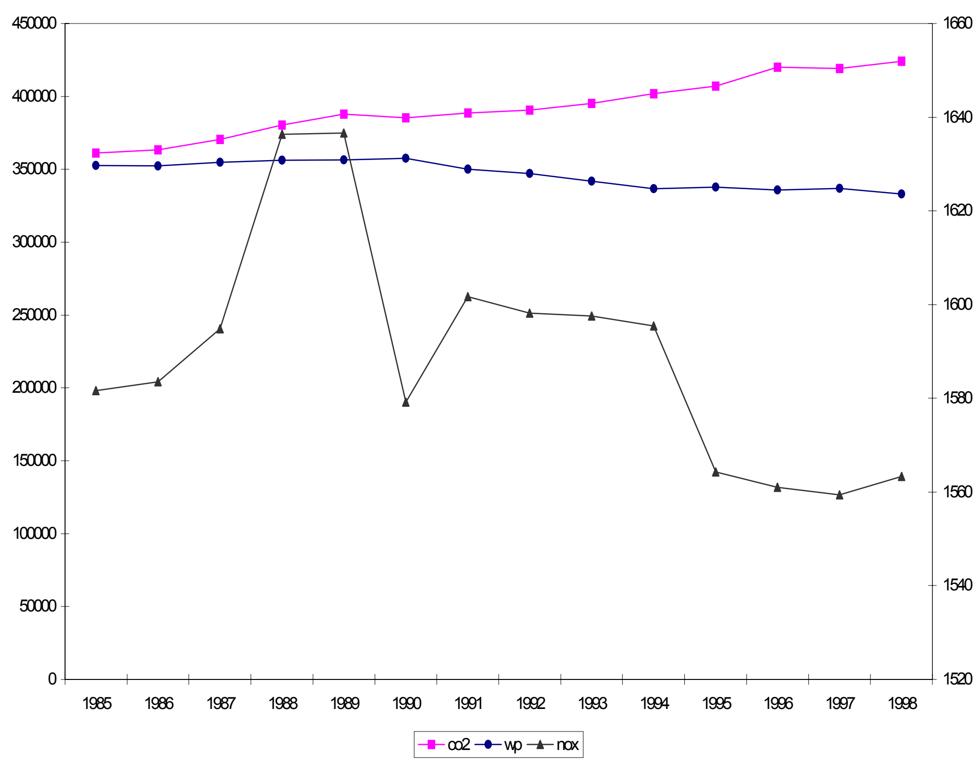
Table 4.3.1. Spearman Correlations of Indices

	index type according to the pollutant that is reduced				
	None	CO2	NOX and CO2	CO2 and Water Pollutant	NOX and Water pollutant
None	1				
CO2	-0,385	1			
NOX and CO2	-0,294	0,487	1		
CO2 and Water Pollutant	0,242	0,071	0,020	1	
NOX and Water pollutant	0,292	-0,128	-0,013	0,693	1

Note that rather than individual sub-periods, these correlations are computed for the whole period 1985-1998. The highest correlation between the Malmquist index and Malmquist-Luenberger index is –0.385. Negative correlation between indices indicates that Malmquist and Malmquist-Luenberger indices move in opposite directions during a negative or positive movement in pollutants.

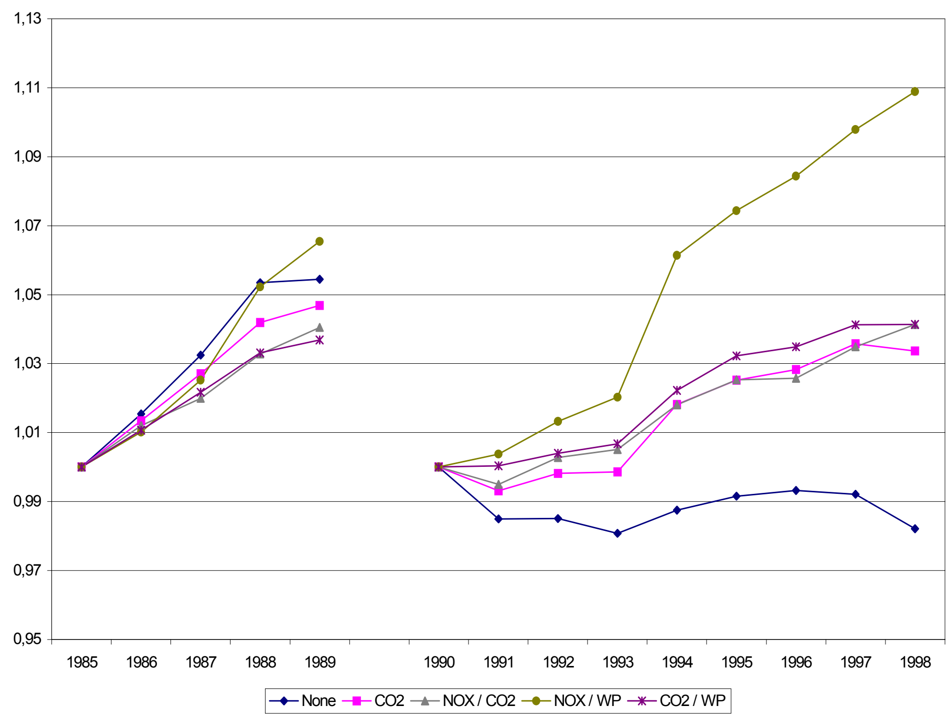
If we consider the annual sub-periods where our pollutants have an increasing path, we would expect that a measure of productivity that explicitly accounts for the joint of goods and bads (Malmquist-Luenberger indices) would exhibit a slower growth than the conventional measures that ignore bads (Malmquist index). However this expectation may not hold if our pollutants move in opposite directions during the time period considered or if there exist a dramatic increase or decrease in the trend of any pollutant. To observe these facts, we first present the trend of pollution emissions of OECD countries in figure 4.3.1.

Figure 4.3.1. The Trend of Pollution Emissions in OECD



The pollutant data for each year is simply calculated by taking the average of 28 individual OECD countries for the period considered. We can clearly see that CO_2 has an increasing path for all years. For NO_X and organic water pollutant data, 1989 can be considered as a break point. Both pollutants increase until 1989 and then decrease for the following years. For the next step, we present the trends in our Malmquist and Malmquist-Luenberger indices together in figure 4.3.2 and try to observe their respective movements according to the changes in undesirable outputs.

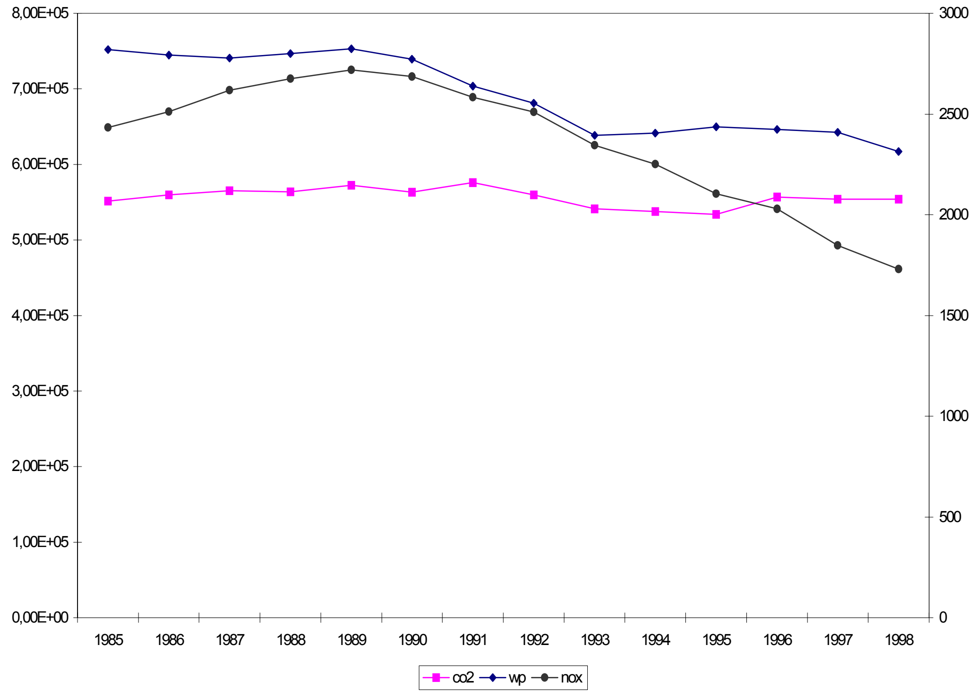
Figure 4.3.2. The Trend of Indices for OECD



For the sub period 1985-1989, the figures 4.3.1 and 4.3.2 support our expectation. During this period, all pollutants have an upward trend. So, we would expect our Malmquist index to over estimate the productivity growth compared to Malmquist-Luenberger indices. For the period 1990-1998, we have an upward trend in CO_2. So, for this sub period, we again expect our Malmquist index to dominate the Malmmquist-Luenberger index that credits the reduction in CO_2. However figure 4.3.2 indicates that Malmquist-Luenberger index exhibits higher productivity growth than the Malmquist index for the time period considered. This fact may be justified if we consider the individual countries rather than the whole sample. We also observe that until 1989 almost all countries have an increasing figure of CO_2. However during the period 1990-1998, some countries that has a large weight of CO_2 in the whole sample has a downward trend. Such an example (Great Britain) will be presented later. For the other pollutants considered, the results support our expectations. Obviously, Malmquist index has a slower growth than the Malmquist-Luenberger index that credits the reduction of NO_X and organic water pollutant during the period 1990-1998 in which both pollutants considered have a downward trend. For the Malmquist-Luenberger indices that credits reduction in NO_X and CO_2 and CO_2 and organic water pollutant, the results may be misleading since CO_2 increases while the other two undesirable outputs decrease during the time span considered. However by taking figure 4.3.2 as our reference, we may say that reductions in NO_X and organic water pollutants dominate the increases in CO_2.

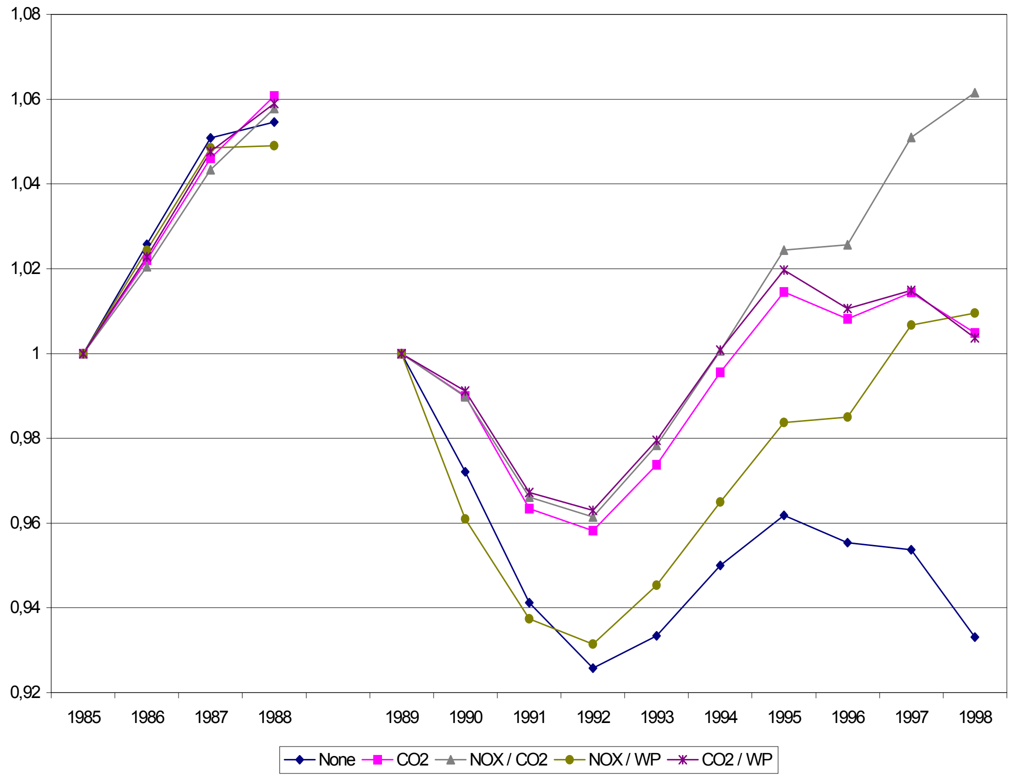
If we turn our attention to individual countries, we again see that our expectations are consistent with the findings. We first choose Great Britain since for all indices; it does not give any infeasible solutions for the whole sub-periods. We again start with the presentation of the annual trends of the pollution emissions for Great Britain in figure 4.3.3.

Figure 4.3.3. The Trend of Pollution Emissions in Great Britain



We can clearly observe that in Great Britain, NO_X increases until 1989 while organic water pollutant and CO_2 has a smooth trend for the same period. Also, NO_X and organic water pollutant have a downward trend in the period 1989-1998 while CO_2 again seems constant for the same period. To make a comparison, we illustrated the Malmquist and Malmquist-Luenberger productivity indices for Great Britain in figure 4.3.4.

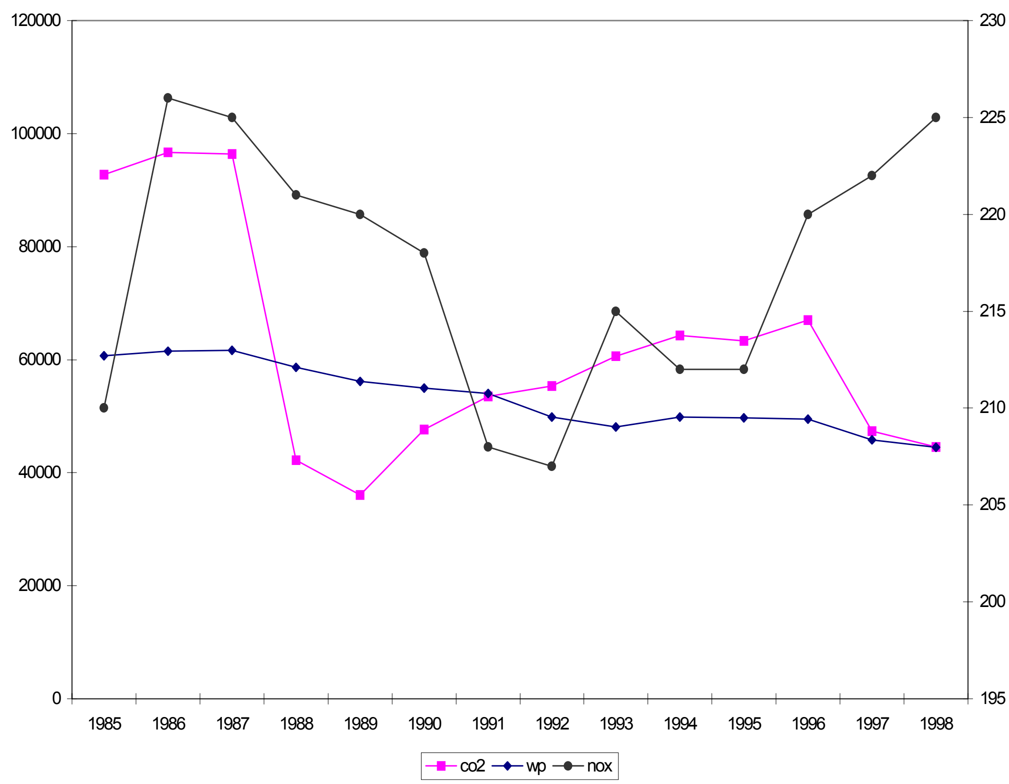
Figure 4.3.4. The Trend of Indices for Great Britain



Until 1989 we can clearly see that Malmquist index shows a higher productivity growth than all Malmquist-Luenberger indices. This finding is consistent with our expectations since for that period NO_X has a very significant upward trend. We also observe that for the period 1987-1988, Malmquist-Luenberger index that credits the reduction in CO_2 produces higher productivity growth rates than the Malmquist index, because of the reduction in the CO_2 for the same period. For the other sub periods 1989-1998, we observe that our Malmquist-Luenberger indices exhibit higher productivity growth than the Malmquist index. This is again expected since for the same time period, the pollutant data for Great Britain has a downward trend.

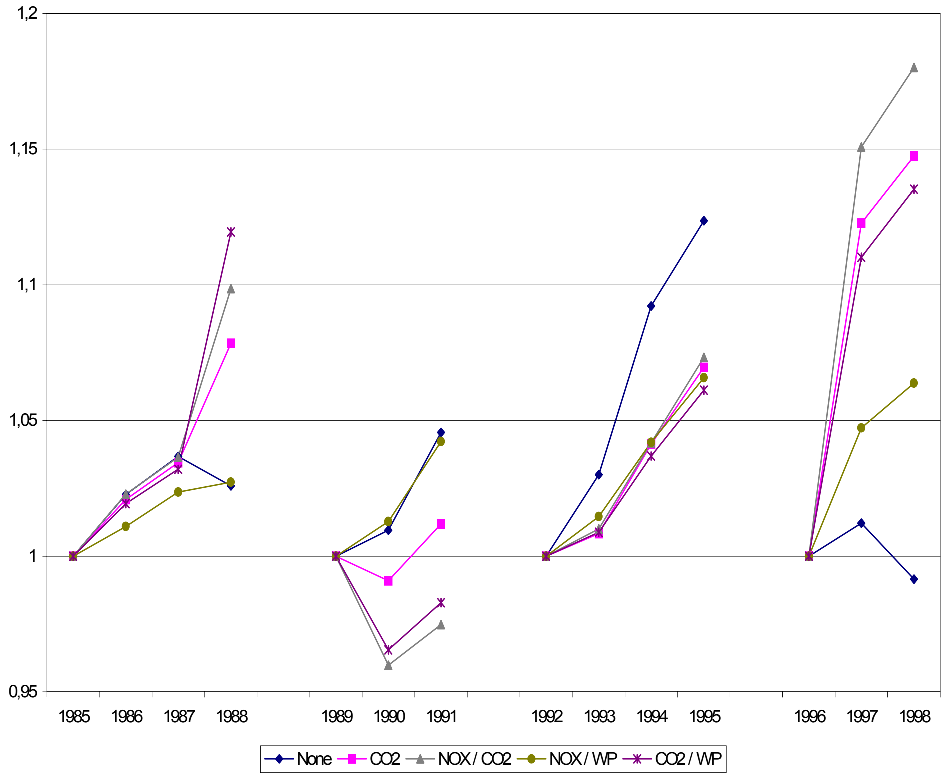
Our second sample country is Norway as one of the best performers in all indices. The path of pollutants in Norway during the time period 1985-1998 is presented in figure 4.3.5.

Figure 4.3.5. The Trend of Pollution Emissions in Norway



A quick glance at figure 4.3.5 reveals that organic water pollutant data for Norway has a downward trend for the whole period. NO_X is decreasing until 1992 and has an upward trend for the other sub-periods. CO_2 data for Norway has a fluctuating trend. It decreases until 1989, then increases from 1989-1996 and for the last two years it decreases again. To make clear exposition, we present the path of indices for Norway in figure 4.3.6 in four different sub-periods.

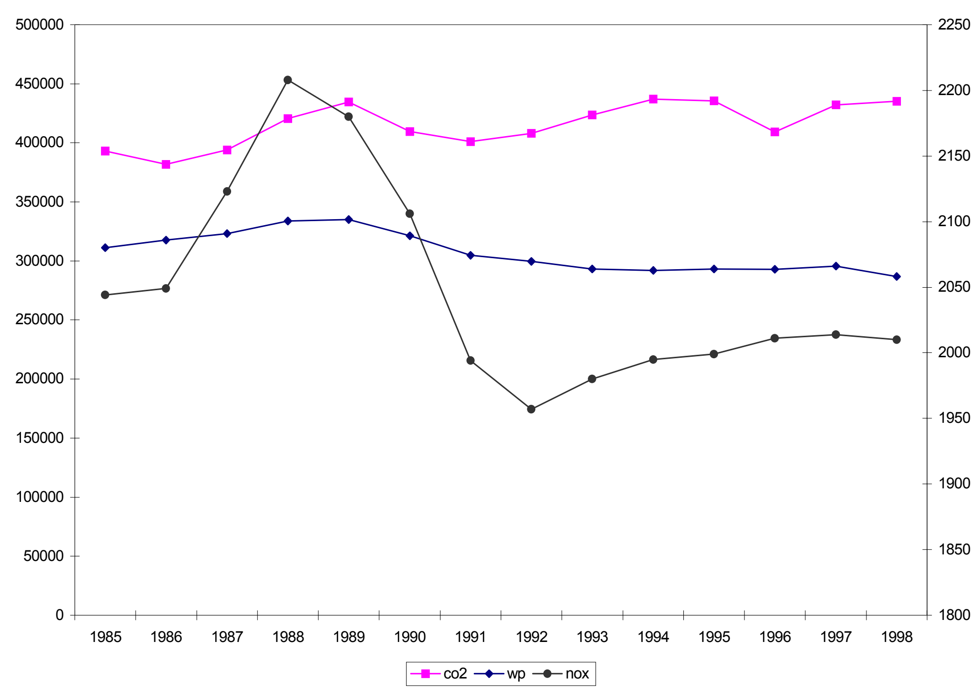
Figure 4.3.6. The Trend of Indices for Norway



For the sub-period 1985-1987, we see that our Malmquist index exhibits a higher productivity growth than Malmquist-Luenberger indices since for the same period the pollutant data for Norway has an upward trend. One significant fact is we can clearly observe the dramatic slowdown in CO_2 from 1987 to 1988, since for that period Malmquist-Luenberger index that credits reduction in CO_2 clearly indicates a higher productivity growth than Malmquist index. For the sub period 1989-1991, we expect Malmquist index to produce higher productivity growth than the Malmquist-Luenberger index that credits the reduction CO_2. However, for the same time period we have a downward trend in NO_X and organic water pollutant, so we expect that Malmquist-Luenberger index that credits the reduction in both pollutants reveals a higher productivity growth than the Malmquist index. It can be seen from figure 4.3.6 that the findings are consistent with our expectations. In sub period 1992-1995, we have a dramatic increase in NO_X and CO_2. We can also observe this fact from figure 4.3.6 since Malmquist index shows a higher productivity growth than all Malmquist-Luenberger indices for the period considered. For the last sub period 1995-1998, we have a decline in organic water pollutant and CO2, so we observe that Malmquist index reveals lower productivity growth for Norway than Malmquist-Luenberger indices.

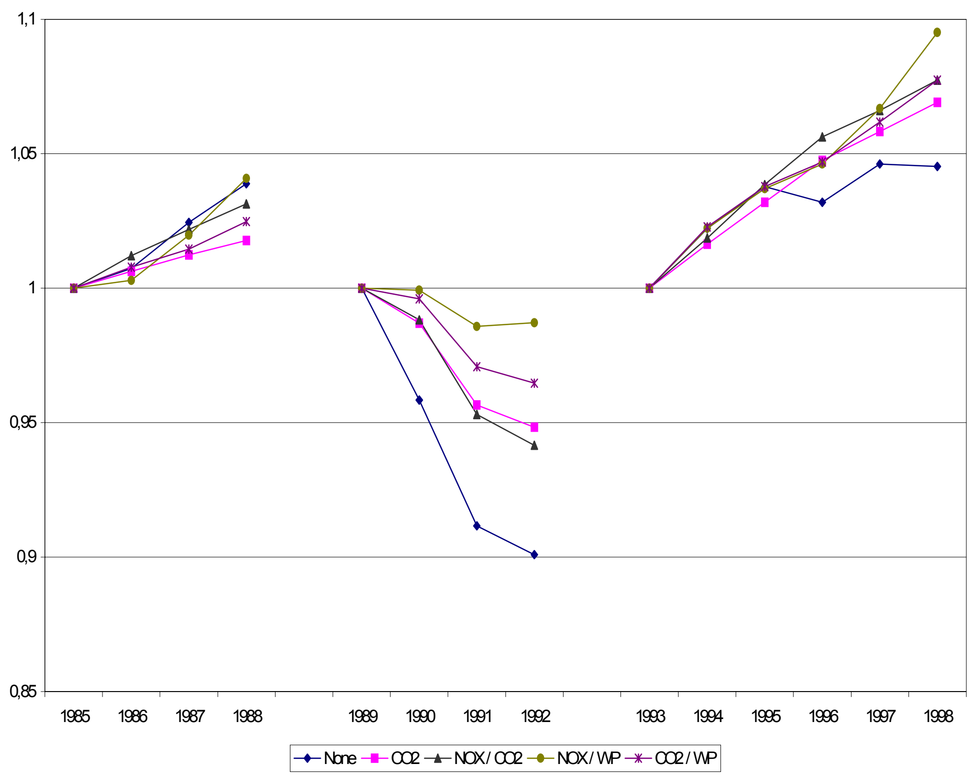
Our last sample country is Canada. We start with plotting the time trend of pollution emissions for Canada in figure 4.3.7.

Figure 4.3.7. The Trend of Pollution Emissions in Canada



We observe that organic water pollutant data for Canada increases from 1985 to 1989, and then has a smooth trend until the end of the period. CO_2 has a fluctuating trend. It increases until 1989 and then decreases from 1989 to 1992 and has an upward trend between 1992 and 1998. On the other hand, NO_X data for Canada increases until 1988 and has a downward trend until 1992. To observe the behavior of our indices for the same sub periods we plot the trends in the productivity indices for Canada in figure 4.3.8 below.

Figure 4.3.8. The Trend of Indices for Canada



For the first sub period Malmquist index reveals a small but higher productivity growth than Malmquist-Luenberger indices. This is expected, since for the same period we observe an upward trend in all pollutants. For the period from 1989 to 1992 we see a dramatic decline in all pollutants, which we can also observe in table 4.3.8 since for the same period all Malmquist-Luenberger indices clearly indicate a higher productivity growth than the Malmquist index. For the last period from 1992 to 1998 we observe that Malmquist and Malmquist-Luenberger indices follows approximately the same path until 1996. We have a decline in CO_2 and organic water pollutant for Canada in 1996. This decline reflects the next period 1996-1998, then we observe that Malmquist-Luenberger indices exhibit a higher productivity growth than the Malmquist index, although we have an upward trend in pollutants.

In the light of the analysis that we presented, we conclude that during the time periods where we observe an upward trend in undesirable outputs, we expect that Malmquist index reveals higher productivity growth than Malmquist-Luenberger index; therefore Malmquist index is biased in the measurement of productivity. On the other hand, for the time periods where we observe a downward trend in pollutants, Malmquist-Luenberger index exhibits a higher productivity growth than Malmquist index so Malmquist productivity index is again biased in the opposite direction.

4.4. Environmental Efficiency Index

We start our analysis by creating a hypothetical country. The data for the hypothetical country is simply calculated by taking the average of all OECD countries for each of the variables considered. Assigning the hypothetical country as our reference, we compute the environmental performance or efficiency of OECD countries. To be in line with the previous sub sections, although our data set includes three undesirable outputs, we do not compute an environmental performance index that uses all three, since such an attempt creates too many infeasible solutions. Similar to the computation of Malmquist Luenberger indices, we employ the pollutant data as pairs and computed environmental performance indices that employ NO_X and CO_2, NO_X and organic water pollutant and CO_2 and organic water pollutant respectively.

For each of the pollutant pairs, we reported two indices namely environmental quantity index and environmental performance index for all of our sample countries during the period 1983 to 1998 in appendix C in tables 4.4.2 to 4.4.7. Environmental quantity indices are simply the index of bads while environmental performance indices that indicate the environmental efficiency are the indices of good output quantity index over bad output quantity index. It should be indicated that, figures greater than 1 (and less than 1) represent a better performance (and an inferior performance) with respect to the hypothetical country (respectively). Note that our hypothetical country takes the value of unity in all indices for all years and is not reported in the tables.

We reported the environmental performance of the OECD countries as an average of the period 1983-1998 in table 4.4.1. Although the ranking and environmental performance of countries differ according to the pollutants considered, it is clear that Poland and Hungary are two best performers for all environmental performance indices while Italy, Japan, Austria and Switzerland are among the worst. One significant fact to note is although USA produces incredible amount of pollutants, she is still environmentally efficient if we consider our pollutant pair as NO_X and CO_2 (see table 4.4.2 and 4.4.3). Table

4.4.1 also makes clear that our indices reveals different environmental performance figures according to the pollutant pairs considered.

Table 4.4.1. Environmental Performance of OECD Countries

Bads	NOX / CO2		NOX / WP		CO2 / WP	
	Index	Rank	Index	Rank	Index	Rank
AUS	1,4384	2	0,7167	26	1,0501	8
AUT	0,5933	26	0,7963	24	0,7783	21
BEL	0,7892	19	0,8985	17	0,9386	16
CAN	1,2971	4	1,1101	12	1,0485	9
DNK	0,9258	12	1,1845	8	1,0029	12
FIN	1,0802	6	1,3816	5	1,0994	6
FRA	0,6039	25	0,8359	21	0,6964	23
GER	0,8065	16	0,8555	19	0,9896	13
GRC	1,0913	5	1,0524	13	0,9681	14
HUN	1,0696	7	1,7187	3	1,5041	2
ISL	N/A	N/A	2,0317	2	N/A	N/A
IRL	1,0397	9	1,1580	9	1,1940	4
ITA	0,6804	21	0,6994	27	0,6467	26
JPN	0,3532	28	N/A	N/A	0,8188	19
KOR	1,0169	10	1,2414	7	1,1787	5
LUX	0,6792	22	0,7977	23	1,3574	3
MEX	0,9181	14	0,5201	28	0,5583	27
NLD	0,8017	17	0,8528	20	0,8360	17
NZL	0,8964	15	1,3442	6	0,9578	15
NOR	1,0494	8	1,0170	16	1,0851	7
POL	2,3854	1	2,6189	1	2,8084	1
PRT	0,6097	24	1,5932	4	0,6882	24
ESP	0,7896	18	1,0238	14	0,8240	18
SWE	0,6249	23	1,0222	15	0,6809	25
CHE	0,4013	27	0,7395	25	0,5323	28
TUR	0,7886	20	0,8894	18	0,7941	20
GBR	0,9436	11	1,1199	10	1,0364	10
USA	1,3164	3	0,8129	22	0,7295	22
MEAN	0,9247	13	1,1171	11	1,0156	11

Further research is also possible to relate these environmental performance indices to Kuznets curve hypothesis by searching the relationship between the GDP per capita income and environmental efficiency indices. If Kuznets curve hypothesis holds, we would expect that environmental performance of sample countries decreases until some threshold level of income and then increases when that level of income is reached. Then, there exist a U-type relationship between the levels of income and environmental performance. Further discussion and application of this hypothesis can be seen in Zaim and Taskin (1999).

CHAPTER 5

CONCLUSION

The objective of this thesis was two folds. The first one is measuring the productivity in the presence of the joint production of the desirable and undesirable outputs and making a clear comparison with a measure that ignores the hazardous by products of production process. Following Fare et al. (1989b) and Chung et al. (1997), Malmquist and Malmquist-Luenberger indices are employed respectively as a measure of productivity. In the light of the analysis presented, we conclude that Malmquist index which does not account for the joint production of goods and bads reveals higher productivity growth than Malmquist-Luenberger indices during the time periods where we observe an upward trend in undesirable outputs. On the other hand, for the time periods where we observe a downward trend in pollutants, Malmquist-Luenberger index dominates Malmquist index. Therefore, Malmquist index is biased in measuring the productivity.

As a second objective, this thesis is aimed to measure the environmental efficiency of OECD countries. For this purpose, an environmental performance index developed in Fare et al. (1999) is adapted. This index relies on the computation of the distance functions within a DEA framework. As we did in the computation of Malmquist-Luenberger indices, we again employ our pollutant data as pairs to avoid from infeasible solutions. Although the ranking and environmental performance of countries differ according to the pollutants considered, we found that Poland and Hungary are two best performers for all environmental performance indices while Italy, Japan, Austria and Switzerland are among the worst. On the other hand, the environmental performance index, which employs the NO_X and organic water pollutant data, reveals significantly higher environmental performance figures than the other indices.

We also noted that further research is needed to relate environmental efficiency indices to Kuznets curve hypothesis.

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APPENDICES

APPENDIX A

Country Codes

AUS: Australia	KOR: Korea
AUT: Austria	LUX: Luxembourg
BEL: Belgium	MEX: Mexico
CAN: Canada	NLD: Netherlands
DNK: Denmark	NZL: New Zealand
FIN: Finland	NOR: Norway
FRA: France	POL: Poland
GER: Germany	PRT: Portugal
GRC: Greece	ESP: Spain
HUN: Hungary	SWE: Sweden
ISL: Iceland	CHE: Switzerland
IRL: Ireland	TUR: Turkey
ITA: Italy	GBR: Great Britain
JPN: Japan	USA: United States of America

APPENDIX B

Table 4.2.3. Malmquist Productivity Index

	1985-1986	1986-1987	1987-1988	1988-1989	1989-1990	1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1985-1998	RANK
AUS	0,9994	1,0276	1,0134	0,9939	0,9748	0,9956	1,0233	1,0315	1,0260	1,0382	0,9910	0,9805	0,9840	1,0792	14
AUT	1,0184	1,0121	1,0218	1,0221	1,0206	1,0054	0,9894	0,9886	1,0017	1,0046	0,9945	0,9888	1,0071	1,0767	15
BEL	1,0161	1,0243	1,0402	1,0075	0,9950	0,9864	0,9899	0,9689	1,0128	0,9912	0,9786	1,0023	0,9921	1,0030	22
CAN	1,0073	1,0170	1,0140	0,9744	0,9584	0,9512	0,9882	1,0105	1,0221	1,0154	0,9944	1,0137	0,9992	0,9632	23
DNK	1,0223	0,9999	1,0121	0,9924	1,0148	1,0196	1,0118	1,0161	1,0522	0,9924	1,0043	1,0020	0,9359	1,0741	16
FIN	1,0135	1,0309	1,0422	1,0546	1,0263	0,9169	0,9740	1,0276	1,0762	1,0842	1,0451	1,0693	1,0424	1,4701	3
FRA	1,0197	1,0164	1,0357	1,0143	0,9955	0,9835	0,9954	0,9865	1,0265	1,0138	1,0007	1,0068	1,0136	1,1124	11
GER	1,0267	1,0159	1,0280	1,0165	1,0070	0,9889	1,0035	0,9822	1,0182	1,0195	0,9943	1,0053	1,0067	1,1174	10
GRC	1,0308	1,0390	1,0475	1,0420	1,0020	1,0157	1,0071	0,9974	1,0294	1,0232	1,0039	1,0019	0,9939	1,2583	6
HUN	1,0112	1,0264	0,9917	1,0068	0,9737	0,9260	1,0277	1,0636	1,0200	1,0355	0,9789	1,0052	0,9962	1,0574	17
ISL	1,0526	1,0488	0,9851	1,0074	0,9962	0,9857	0,9637	1,0308	1,0540	1,0208	1,0427	1,0204	0,9731	1,1905	7
IRL	0,9914	1,0536	1,0609	1,0418	1,0508	1,0016	1,0437	1,0497	1,0760	1,0851	1,0226	1,0305	1,0025	1,6419	1
ITA	1,0242	1,0270	1,0303	1,0102	0,9994	0,9900	0,9903	0,9913	1,0265	1,0258	0,9957	1,0004	0,9961	1,1110	12
JPN	1,0117	1,0198	1,0291	0,9984	0,9949	0,9852	0,9709	0,9754	0,9824	0,9884	1,0215	0,9878	0,9564	0,9221	27
KOR	1,0188	1,0156	1,0077	0,9622	0,9760	0,9693	0,9499	0,9661	0,9876	1,0037	0,9929	0,9781	0,8961	0,7514	29
LUX	1,0658	1,0071	1,0884	1,0564	1,0033	1,0290	1,0252	1,0342	1,0177	1,0159	1,0059	1,0428	1,0230	1,4987	2
MEX	0,9732	1,0261	1,0261	1,0501	1,0473	1,0255	1,0118	0,9945	1,0177	0,9550	1,0223	1,0074	1,0065	1,1715	8
NLD	1,0154	1,0005	1,0151	1,0222	1,0159	1,0023	1,0025	0,9979	1,0171	1,0128	1,0022	1,0074	1,0037	1,1209	9
NZL	1,0017	1,0003	1,0052	0,9881	0,9816	0,9902	1,0101	1,0383	1,0118	0,9272	0,9834	0,9814	1,0380	0,9535	25
NOR	1,0227	1,0137	0,9895	0,9994	1,0095	1,0358	1,0350	1,0300	1,0603	1,0289	1,0412	1,0121	0,9797	1,2871	5
POL	1,0714	1,0481	1,0627	1,0234	0,9579	1,0308	1,0746	1,0783	1,0434	1,0329	1,0114	0,9943	0,9653	1,4619	4
PRT	1,0536	1,0475	1,0304	0,9817	0,9888	0,9883	0,9779	0,9611	0,9913	0,9900	0,9916	0,9838	0,9541	0,9366	26
ESP	1,0322	1,0444	1,0243	1,0050	0,9859	0,9746	0,9682	0,9642	1,0031	1,0331	0,9841	0,9980	0,9968	1,0099	21
SWE	1,0158	1,0144	1,0010	0,9897	0,9824	0,9750	0,9773	1,0027	1,0477	1,0695	0,9915	1,0074	1,0068	1,0797	13
CHE	0,9992	0,9950	1,0288	1,0322	0,9687	0,9613	0,9861	0,9864	0,9881	0,9513	1,0243	0,8653	1,1108	0,8850	28
TUR	1,0357	1,0171	0,9795	0,9743	1,0651	0,9850	1,0061	1,0195	0,8972	1,0383	1,0233	1,0184	0,9648	1,0133	20
GBR	1,0258	1,0244	1,0036	0,9713	0,9721	0,9682	0,9836	1,0082	1,0179	1,0124	0,9933	0,9983	0,9783	0,9558	24
USA	1,0108	1,0085	1,0148	0,9971	0,9886	0,9843	1,0194	1,0034	1,0051	0,9952	0,9978	1,0011	0,9993	1,0251	19
GEOMEAN	1,0154	1,0168	1,0203	1,0010	0,9934	0,9850	1,0001	0,9956	1,0069	1,0041	1,0017	0,9988	0,9900	1,0288	18

Table 4.2.4. Malmquist Productivity Index (Efficiency Change)

	1985-1986	1986-1987	1987-1988	1988-1989	1989-1990	1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1985-1998	RANK
AUS	0,9407	1,0237	0,9563	0,9778	0,9748	0,9988	1,0413	1,0308	1,0188	1,0389	0,9929	0,9861	0,9798	0,9555	21
AUT	0,9524	1,0005	0,9470	1,0022	1,0206	1,0071	1,0206	0,9949	0,9977	1,0073	0,9994	0,9965	1,0032	0,9477	22
BEL	0,9683	1,0157	1,0028	0,9990	0,9950	0,9892	1,0151	0,9727	1,0077	0,9933	0,9827	1,0097	0,9882	0,9398	23
CAN	0,9699	1,0097	0,9597	0,9568	0,9584	0,9526	1,0184	1,0154	1,0171	1,0174	0,9978	1,0204	0,9951	0,8901	26
DNK	0,9724	0,9936	0,9703	0,9846	1,0148	1,0245	1,0215	1,0126	1,0472	0,9930	1,0058	1,0073	0,9318	0,9745	13
FIN	0,9478	1,0191	0,9394	0,9670	1,0199	0,8843	0,9758	1,0370	1,0726	1,0867	1,0485	1,0757	1,0378	1,0925	6
FRA	0,9536	1,0047	0,9527	0,9924	0,9955	0,9843	1,0314	0,9939	1,0224	1,0163	1,0049	1,0138	1,0094	0,9722	15
GER	0,9601	1,0043	0,9502	0,9987	1,0070	0,9908	1,0333	0,9868	1,0132	1,0214	0,9977	1,0117	1,0024	0,9747	12
GRC	1,0308	1,0463	1,0410	1,0420	1,0007	1,0220	1,0146	0,9931	1,0274	1,0232	1,0026	1,0067	0,9939	1,2713	3
HUN	1,0100	1,0242	0,9878	1,0068	0,9666	0,9295	1,0324	1,0553	1,0188	1,0355	0,9757	1,0083	0,9962	1,0412	8
ISL	0,9998	1,0419	0,9437	1,0005	0,9962	0,9906	0,9722	1,0276	1,0516	1,0208	1,0423	1,0261	0,9731	1,0833	7
IRL	0,9914	1,0612	1,0541	1,0418	1,0500	1,0081	1,0520	1,0458	1,0736	1,0851	1,0222	1,0363	1,0000	1,6604	1
ITA	0,9578	1,0153	0,9416	0,9845	0,9994	0,9907	1,0262	0,9989	1,0224	1,0283	0,9998	1,0073	0,9920	0,9610	20
JPN	0,9922	1,0089	1,0052	0,9906	0,9949	0,9869	1,0047	0,9839	0,9796	0,9917	1,0275	0,9962	0,9528	0,9166	25
KOR	1,0177	1,0159	1,0027	0,9622	0,9733	0,9750	0,9571	0,9627	0,9846	1,0043	0,9956	0,9848	0,8924	0,7546	28
LUX	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	10
MEX	0,9725	1,0267	1,0215	1,0501	1,0404	1,0296	1,0168	0,9870	1,0164	0,9550	1,0183	1,0099	1,0065	1,1568	4
NLD	0,9496	0,9891	0,9483	1,0045	1,0159	1,0048	1,0229	0,9970	1,0112	1,0130	1,0030	1,0123	0,9991	0,9678	16
NZL	1,0016	1,0074	0,9987	0,9881	0,9808	0,9964	1,0178	1,0342	1,0097	0,9272	0,9828	0,9866	1,0380	0,9651	17
NOR	0,9565	1,0021	0,8918	0,9164	1,0029	0,9917	0,9930	0,9746	1,0603	1,0297	1,0508	1,0229	0,9765	0,8640	27
POL	1,0692	1,0378	1,0609	1,0234	0,9442	1,0315	1,0753	1,0677	1,0434	1,0329	1,0068	0,9947	0,9653	1,4035	2
PRT	1,0525	1,0468	1,0258	0,9817	0,9844	0,9933	0,9843	0,9561	0,9894	0,9900	0,9903	0,9885	0,9541	0,9340	24
ESP	1,0320	1,0512	1,0179	1,0050	0,9852	0,9809	0,9759	0,9609	1,0009	1,0331	0,9839	1,0050	0,9949	1,0231	9
SWE	1,0158	1,0220	0,9945	0,9897	0,9820	0,9814	0,9852	0,9993	1,0454	1,0695	0,9910	1,0130	1,0068	1,0956	5
CHE	0,9345	0,9836	0,9273	0,9464	0,9624	0,9204	0,9508	0,9880	0,9876	0,9556	1,0318	0,8733	1,1068	0,6318	29
TUR	1,0326	1,0000	0,9795	0,9743	1,0479	0,9851	1,0064	1,0087	0,8972	1,0383	1,0204	1,0184	0,9648	0,9645	18
GBR	1,0254	1,0291	0,9978	0,9713	0,9703	0,9740	0,9908	1,0039	1,0158	1,0124	0,9925	1,0036	0,9783	0,9634	19
USA	1,0000	1,0000	1,0000	0,9947	0,9886	0,9892	1,0281	1,0000	1,0000	0,9953	0,9987	1,0060	0,9948	0,9948	11
GEOMEAN	0,9891	1,0092	0,9870	0,9917	0,9923	0,9875	1,0174	0,9957	1,0030	1,0052	1,0037	1,0046	0,9865	0,9727	14

Table 4.2.5. Malmquist Productivity Index (Technical Change)

	1985-1986	1986-1987	1987-1988	1988-1989	1989-1990	1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1985-1998	RANK
AUS	1,0624	1,0038	1,0597	1,0165	1,0000	0,9968	0,9827	1,0007	1,0071	0,9993	0,9981	0,9943	1,0044	1,1296	10
AUT	1,0694	1,0116	1,0789	1,0198	1,0000	0,9984	0,9694	0,9937	1,0040	0,9973	0,9951	0,9923	1,0039	1,1362	9
BEL	1,0494	1,0085	1,0373	1,0085	1,0000	0,9972	0,9752	0,9960	1,0050	0,9979	0,9958	0,9927	1,0039	1,0673	14
CAN	1,0385	1,0073	1,0566	1,0184	1,0000	0,9986	0,9704	0,9951	1,0049	0,9980	0,9966	0,9934	1,0042	1,0822	13
DNK	1,0514	1,0064	1,0431	1,0080	1,0000	0,9952	0,9905	1,0034	1,0048	0,9995	0,9985	0,9947	1,0045	1,1026	11
FIN	1,0693	1,0116	1,1095	1,0906	1,0063	1,0369	0,9982	0,9910	1,0034	0,9977	0,9967	0,9941	1,0044	1,3460	4
FRA	1,0694	1,0116	1,0871	1,0221	1,0000	0,9992	0,9651	0,9926	1,0040	0,9975	0,9958	0,9931	1,0041	1,1442	8
GER	1,0694	1,0116	1,0819	1,0178	1,0000	0,9981	0,9712	0,9953	1,0050	0,9981	0,9966	0,9937	1,0043	1,1466	7
GRC	1,0000	0,9931	1,0063	1,0000	1,0013	0,9939	0,9926	1,0044	1,0020	1,0000	1,0013	0,9952	1,0000	0,9900	25
HUN	1,0012	1,0022	1,0040	1,0000	1,0073	0,9963	0,9954	1,0079	1,0012	1,0000	1,0034	0,9969	1,0000	1,0158	19
ISL	1,0529	1,0067	1,0438	1,0069	1,0000	0,9950	0,9913	1,0031	1,0023	1,0000	1,0003	0,9945	1,0000	1,0990	12
IRL	1,0000	0,9929	1,0064	1,0000	1,0008	0,9936	0,9922	1,0037	1,0022	1,0000	1,0004	0,9944	1,0025	0,9890	26
ITA	1,0694	1,0116	1,0942	1,0262	1,0000	0,9993	0,9650	0,9924	1,0040	0,9976	0,9959	0,9931	1,0041	1,1563	6
JPN	1,0197	1,0108	1,0238	1,0078	1,0000	0,9982	0,9664	0,9914	1,0029	0,9967	0,9942	0,9916	1,0038	1,0061	21
KOR	1,0010	0,9997	1,0050	1,0000	1,0028	0,9941	0,9924	1,0035	1,0031	0,9994	0,9973	0,9932	1,0041	0,9955	23
LUX	1,0658	1,0071	1,0884	1,0564	1,0033	1,0290	1,0252	1,0342	1,0177	1,0159	1,0059	1,0428	1,0230	1,4987	1
MEX	1,0008	0,9994	1,0045	1,0000	1,0066	0,9960	0,9951	1,0076	1,0013	1,0000	1,0040	0,9975	1,0000	1,0128	20
NLD	1,0694	1,0116	1,0705	1,0176	1,0000	0,9975	0,9800	1,0009	1,0059	0,9999	0,9992	0,9951	1,0046	1,1584	5
NZL	1,0002	0,9930	1,0065	1,0000	1,0009	0,9938	0,9925	1,0040	1,0021	1,0000	1,0006	0,9946	1,0000	0,9882	27
NOR	1,0692	1,0116	1,1095	1,0906	1,0066	1,0444	1,0423	1,0569	1,0000	0,9993	0,9909	0,9895	1,0032	1,4898	2
POL	1,0020	1,0099	1,0017	1,0000	1,0145	0,9993	0,9993	1,0100	1,0000	1,0000	1,0046	0,9997	1,0000	1,0416	17
PRT	1,0010	1,0006	1,0045	1,0000	1,0045	0,9949	0,9936	1,0052	1,0018	1,0000	1,0014	0,9952	1,0000	1,0026	22
ESP	1,0001	0,9936	1,0063	1,0000	1,0007	0,9936	0,9921	1,0034	1,0022	1,0000	1,0002	0,9930	1,0019	0,9871	28
SWE	1,0000	0,9925	1,0065	1,0000	1,0004	0,9935	0,9920	1,0035	1,0022	1,0000	1,0004	0,9945	1,0000	0,9855	29
CHE	1,0692	1,0116	1,1095	1,0906	1,0066	1,0444	1,0371	0,9984	1,0005	0,9955	0,9927	0,9908	1,0036	1,4007	3
TUR	1,0031	1,0171	1,0000	1,0000	1,0164	1,0000	0,9998	1,0107	1,0000	1,0000	1,0029	1,0000	1,0000	1,0509	16
GBR	1,0004	0,9955	1,0058	1,0000	1,0019	0,9940	0,9927	1,0043	1,0020	1,0000	1,0008	0,9948	1,0000	0,9921	24
USA	1,0108	1,0085	1,0148	1,0024	1,0000	0,9951	0,9915	1,0034	1,0051	0,9998	0,9991	0,9951	1,0045	1,0303	18
GEOMEAN	1,0266	1,0075	1,0337	1,0094	1,0011	0,9974	0,9830	1,0000	1,0039	0,9989	0,9980	0,9943	1,0036	1,0579	15

Table 4.2.6. Malmquist-Luenberger Productivity Index

Bads: CO_2

	1985-1986	1986-1987	1987-1988	1988-1989	1989-1990	1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1985-1998	RANK
AUS	1,0030	1,0131	1,0124	0,9954	0,9750	1,0001	1,0190	1,0218	1,0160	1,0258	0,9869	0,9979	0,9961	1,0629	19
AUT	1,0142	1,0045	1,0234	1,0186	1,0117	1,0087	1,0032	0,9945	1,0046	1,0051	1,0069	1,0043	1,0204	1,1266	10
BEL	1,0211	1,0215	1,0490	1,0067	1,0011	0,9899	1,0026	0,9922	1,0019	0,9974	0,9928	1,0255	1,0112	1,1171	15
CAN	1,0063	1,0061	1,0052	0,9909	0,9870	0,9692	0,9914	1,0049	1,0163	1,0154	1,0151	1,0103	1,0102	1,0275	23
DNK	1,0178	1,0021	1,0280	1,0191	1,0021	0,9804	1,0352	0,9999	1,0329	1,0148	1,0068	1,0146	0,9689	1,1273	9
FIN	0,9943	1,0220	1,0344	1,0176	0,9872	0,9385	0,9918	1,0097	1,0299	1,0637	0,9961	1,0625	1,0321	1,1876	3
FRA	1,0264	1,0188	1,0427	1,0038	1,0031	0,9854	1,0067	0,9920	1,0331	1,0101	0,9922	1,0269	1,0242	1,1765	4
GER	1,0163	1,0118	1,0205	1,0129	1,0118	0,9980	1,0110	0,9896	1,0235	1,0134	0,9949	1,0138	1,0131	1,1381	7
GRC	1,0220	1,0076	1,0269	1,0187	1,0035	1,0285	0,9865	0,9861	1,0155	1,0220	0,9993	1,0038	0,9989	1,1247	12
HUN	1,0175	1,0232	0,9997	1,0092	0,9883	0,9336	1,0312	1,0515	1,0264	1,0267	0,9792	1,0363	1,0163	1,1420	6
ISL	1,0277	1,0368	0,9837	1,0031	0,9940	1,0049	0,9659	1,0051	1,0349	1,0257	1,0128	1,0310	0,9906	1,1195	14
IRL	0,9757	1,0316	1,0411	1,0455	1,0431	0,9897	1,0431	1,0298	1,0525	1,0506	1,0369	1,0373	1,0152	1,4669	1
ITA	1,0202	1,0130	1,0214	1,0033	1,0025	0,9974	0,9948	0,9971	1,0227	1,0162	1,0048	0,9994	1,0041	1,1007	16
JPN	1,0074	1,0168	0,9939	1,0035	0,9996	0,9990	0,9889	0,9974	0,9824	0,9972	1,0237	0,9988	0,9743	0,9820	28
KOR	1,0294	1,0260	1,0127	0,9962	1,0031	0,9910	0,9703	0,9813	1,0125	1,0134	1,0097	1,0089	0,9316	0,9820	27
LUX	INF	1,0069	INF	INF	INF	INF	INF	INF	1,0229	1,0484	1,0074	INF	INF	1,0803	18
MEX	0,9812	1,0093	1,0217	1,0382	1,0360	1,0187	1,0062	0,9993	1,0124	0,9635	1,0092	1,0131	1,0100	1,1229	13
NLD	1,0227	1,0044	1,0195	1,0005	1,0177	1,0007	1,0040	0,9983	1,0198	1,0166	0,9870	1,0198	1,0121	1,1295	8
NZL	0,9933	0,9958	0,9960	0,9883	0,9970	0,9800	1,0003	1,0401	1,0138	0,9412	0,9809	0,9920	1,0237	0,9407	29
NOR	1,0209	1,0133	1,0425	1,0092	0,9910	1,0210	1,0251	1,0084	1,0326	1,0272	1,0167	1,1228	1,0220	1,4087	2
POL	INF	INF	INF	1,0107	0,8353	1,0761	1,1351	INF	INF	INF	INF	1,0019	0,9675	0,9996	25
PRT	1,0460	1,0237	1,0358	0,9770	1,0059	1,0026	0,9814	0,9793	0,9985	0,9890	1,0027	0,9818	0,9675	0,9879	26
ESP	1,0454	1,0338	1,0246	0,9987	1,0003	0,9846	0,9752	0,9820	0,9976	1,0331	1,0061	1,0199	1,0198	1,1249	11
SWE	1,0158	1,0211	1,0072	1,0069	1,0114	0,9764	0,9741	1,0277	1,0121	1,0695	0,9870	1,0301	1,0200	1,1673	5
CHE	0,9987	1,0015	1,0169	1,0274	0,9800	0,9985	0,9953	1,0155	0,9932	1,0066	0,9801	0,9308	1,0750	1,0133	24
TUR	1,0230	1,0137	1,0101	0,9676	1,0510	0,9974	1,0102	1,0165	0,9383	1,0127	1,0221	1,0222	0,9766	1,0578	21
GBR	1,0220	1,0236	1,0140	0,9906	0,9900	0,9731	0,9947	1,0162	1,0224	1,0190	0,9937	1,0062	0,9906	1,0559	22
USA	1,0109	1,0102	1,0131	1,0062	1,0024	0,9908	1,0154	1,0029	1,0056	1,0021	0,9991	1,0030	0,9993	1,0625	20
GEOMEAN	1,0134	1,0135	1,0144	1,0048	1,0009	0,9931	1,0051	1,0004	1,0196	1,0069	1,0030	1,0073	0,9980	1,0831	17

Table 4.2.7. Malmquist-Luenberger Productivity Index (Efficiency Change)

Bads: CO_2

	1985-1986	1986-1987	1987-1988	1988-1989	1989-1990	1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1985-1998	RANK
AUS	1,0003	1,0085	1,0027	0,9848	0,9729	1,0001	1,0193	1,0331	1,0084	0,9937	0,9789	0,9785	0,9802	0,9602	24
AUT	1,0131	0,9997	1,0243	1,0077	1,0078	1,0087	1,0127	1,0169	0,9974	0,9870	1,0115	1,0012	0,9987	1,0896	5
BEL	1,0186	1,0159	1,0287	1,0000	1,0000	0,9899	1,0049	0,9993	0,9925	0,9468	0,9932	1,0175	0,9952	1,0001	17
CAN	1,0031	1,0009	0,9963	0,9796	0,9849	0,9692	0,9956	1,0120	1,0069	0,9668	1,0149	1,0014	0,9957	0,9284	26
DNK	1,0163	0,9970	1,0162	1,0119	0,9978	0,9804	1,0368	1,0167	1,0241	0,9630	1,0071	1,0019	0,9508	1,0165	13
FIN	0,9938	1,0200	1,0358	1,0072	0,9866	0,9385	1,0055	1,0357	1,0239	1,0432	0,9981	1,0518	1,0137	1,1591	3
FRA	1,0260	1,0142	1,0440	0,9922	0,9993	0,9854	1,0183	1,0177	1,0304	0,9889	0,9970	1,0189	1,0000	1,1386	4
GER	1,0153	1,0079	1,0115	1,0061	1,0101	0,9980	1,0176	1,0034	1,0099	0,9854	0,9968	1,0044	0,9948	1,0624	6
GRC	1,0180	0,9975	1,0167	1,0163	1,0008	1,0344	0,9868	0,9914	1,0201	0,9917	0,9911	0,9817	0,9912	1,0367	8
HUN	1,0064	1,0046	0,9931	1,0092	0,9814	0,9463	1,0315	1,0422	1,0299	1,0136	0,9822	1,0121	1,0107	1,0611	7
ISL	1,0248	1,0306	0,9813	0,9946	0,9883	1,0049	0,9698	1,0277	1,0235	0,9621	1,0114	1,0149	0,9747	1,0052	14
IRL	0,9745	1,0231	1,0317	1,0431	1,0411	0,9934	1,0420	1,0380	1,0472	1,0319	1,0179	1,0000	1,0000	1,3202	1
ITA	1,0197	1,0091	1,0163	0,9947	1,0012	0,9974	1,0041	1,0134	1,0060	0,9917	1,0073	0,9907	0,9851	1,0366	9
JPN	1,0035	1,0159	0,9898	0,9874	0,9987	1,0040	1,0022	1,0104	0,9805	0,9872	1,0302	1,0108	0,9670	0,9860	21
KOR	1,0064	0,9976	0,9839	0,9941	0,9987	1,0006	0,9700	0,9998	1,0054	0,9779	1,0125	1,0025	0,9177	0,8716	27
LUX	INF	1,0000	INF	INF	INF	INF	INF	INF	1,0000	1,0000	1,0000	INF	INF	1,0000	18
MEX	0,9691	0,9778	0,9949	1,0382	1,0317	1,0362	1,0068	0,9911	1,0176	0,9472	1,0194	0,9870	1,0057	1,0183	11
NLD	1,0210	1,0004	1,0075	0,9920	1,0174	1,0007	1,0072	1,0127	1,0110	0,9616	0,9856	1,0070	0,9952	1,0180	12
NZL	0,9928	0,9879	0,9867	0,9854	0,9935	0,9842	1,0005	1,0514	1,0082	0,8973	0,9758	0,9807	1,0141	0,8611	29
NOR	0,9853	1,0053	1,0007	0,9769	0,9910	1,0177	1,0412	1,0130	1,0226	0,9859	1,0185	1,1302	1,0057	1,2022	2
POL	INF	INF	INF	1,0000	0,8353	1,0761	1,1125	INF	INF	INF	INF	0,9999	0,9675	0,9674	23
PRT	1,0066	1,0000	1,0000	0,9769	1,0054	1,0182	0,9815	0,9829	1,0075	0,9404	1,0063	0,9737	0,9584	0,8640	28
ESP	1,0396	1,0212	1,0136	0,9955	0,9965	0,9865	0,9746	1,0024	0,9852	0,9694	1,0060	1,0021	0,9966	0,9872	20
SWE	1,0158	1,0116	1,0000	1,0000	1,0000	0,9764	0,9742	1,0512	1,0000	1,0000	0,9867	1,0135	1,0000	1,0275	10
CHE	0,9982	1,0014	1,0004	1,0000	0,9798	0,9986	1,0172	1,0048	0,9932	1,0066	0,9842	0,9383	1,0832	1,0001	16
TUR	1,0000	1,0000	1,0000	0,9676	1,0335	0,9995	1,0005	1,0000	0,9379	1,0067	1,0591	1,0000	0,9762	0,9762	22
GBR	1,0091	1,0000	1,0000	0,9904	0,9896	0,9816	0,9952	1,0192	1,0229	0,9892	0,9804	0,9827	0,9817	0,9424	25
USA	1,0000	1,0000	1,0000	1,0000	1,0000	0,9909	1,0091	1,0000	1,0000	1,0000	0,9990	1,0010	0,9986	0,9985	19
GEOMEAN	1,0060	1,0045	1,0038	0,9969	0,9984	0,9954	1,0069	1,0066	1,0017	0,9892	1,0046	1,0017	0,9895	1,0050	15

Table 4.2.8. Malmquist-Luenberger Productivity Index (Technical Change)

Bads: CO_2

	1985-1986	1986-1987	1987-1988	1988-1989	1989-1990	1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1985-1998	RANK
AUS	1,0026	1,0045	1,0096	1,0108	1,0022	1,0000	0,9997	0,9891	1,0076	1,0324	1,0081	1,0199	1,0162	1,1070	12
AUT	1,0010	1,0048	0,9991	1,0108	1,0039	1,0000	0,9906	0,9780	1,0072	1,0184	0,9954	1,0031	1,0218	1,0338	24
BEL	1,0024	1,0056	1,0198	1,0067	1,0011	1,0000	0,9978	0,9929	1,0094	1,0534	0,9995	1,0078	1,0160	1,1169	7
CAN	1,0032	1,0052	1,0089	1,0115	1,0022	1,0000	0,9958	0,9930	1,0093	1,0502	1,0002	1,0089	1,0146	1,1068	13
DNK	1,0015	1,0051	1,0116	1,0071	1,0043	1,0000	0,9985	0,9835	1,0087	1,0538	0,9997	1,0126	1,0191	1,1091	11
FIN	1,0005	1,0019	0,9987	1,0103	1,0006	1,0000	0,9863	0,9749	1,0059	1,0196	0,9980	1,0102	1,0182	1,0245	27
FRA	1,0003	1,0046	0,9987	1,0117	1,0038	1,0000	0,9886	0,9747	1,0026	1,0215	0,9952	1,0079	1,0242	1,0333	26
GER	1,0010	1,0038	1,0090	1,0068	1,0017	1,0000	0,9935	0,9863	1,0134	1,0284	0,9981	1,0093	1,0185	1,0713	20
GRC	1,0040	1,0102	1,0101	1,0023	1,0027	0,9943	0,9997	0,9947	0,9955	1,0306	1,0082	1,0226	1,0078	1,0852	16
HUN	1,0111	1,0186	1,0066	1,0000	1,0070	0,9865	0,9997	1,0089	0,9966	1,0129	0,9970	1,0240	1,0056	1,0765	19
ISL	1,0028	1,0060	1,0024	1,0086	1,0058	1,0000	0,9960	0,9780	1,0111	1,0661	1,0013	1,0159	1,0164	1,1137	8
IRL	1,0012	1,0083	1,0091	1,0023	1,0019	0,9963	1,0011	0,9921	1,0050	1,0181	1,0187	1,0373	1,0152	1,1111	9
ITA	1,0005	1,0038	1,0050	1,0087	1,0014	1,0000	0,9907	0,9839	1,0165	1,0247	0,9975	1,0088	1,0193	1,0617	23
JPN	1,0038	1,0009	1,0041	1,0163	1,0009	0,9951	0,9867	0,9872	1,0019	1,0102	0,9937	0,9881	1,0075	0,9959	29
KOR	1,0229	1,0285	1,0293	1,0022	1,0043	0,9904	1,0002	0,9815	1,0071	1,0363	0,9972	1,0064	1,0152	1,1268	5
LUX	INF	1,0069	INF	INF	INF	INF	INF	INF	1,0229	1,0484	1,0074	INF	INF	1,0803	18
MEX	1,0125	1,0322	1,0270	1,0000	1,0042	0,9832	0,9994	1,0082	0,9950	1,0172	0,9900	1,0265	1,0043	1,1030	14
NLD	1,0016	1,0040	1,0118	1,0085	1,0003	1,0000	0,9967	0,9858	1,0087	1,0572	1,0015	1,0128	1,0169	1,1093	10
NZL	1,0005	1,0079	1,0094	1,0029	1,0035	0,9957	0,9998	0,9893	1,0055	1,0489	1,0052	1,0115	1,0094	1,0920	15
NOR	1,0362	1,0079	1,0418	1,0331	1,0000	1,0032	0,9845	0,9955	1,0098	1,0419	0,9982	0,9934	1,0163	1,1718	1
POL	INF	INF	INF	1,0107	1,0000	1,0000	1,0204	INF	INF	INF	INF	1,0020	1,0000	1,0334	25
PRT	1,0391	1,0237	1,0358	1,0001	1,0006	0,9846	1,0000	0,9963	0,9911	1,0517	0,9964	1,0083	1,0095	1,1434	2
ESP	1,0056	1,0123	1,0109	1,0032	1,0038	0,9981	1,0006	0,9796	1,0125	1,0656	1,0001	1,0177	1,0233	1,1392	3
SWE	1,0000	1,0095	1,0072	1,0069	1,0114	1,0000	0,9998	0,9776	1,0121	1,0695	1,0003	1,0163	1,0200	1,1360	4
CHE	1,0005	1,0001	1,0166	1,0274	1,0002	0,9999	0,9785	1,0107	1,0000	1,0000	0,9959	0,9919	0,9924	1,0133	28
TUR	1,0230	1,0137	1,0101	1,0000	1,0170	0,9979	1,0097	1,0165	1,0004	1,0060	0,9650	1,0222	1,0004	1,0836	17
GBR	1,0127	1,0236	1,0140	1,0002	1,0003	0,9914	0,9995	0,9971	0,9995	1,0301	1,0136	1,0239	1,0091	1,1204	6
USA	1,0109	1,0102	1,0131	1,0062	1,0024	0,9999	1,0062	1,0029	1,0056	1,0021	1,0001	1,0020	1,0007	1,0640	22
GEOMEAN	1,0073	1,0090	1,0106	1,0079	1,0024	0,9977	0,9983	0,9939	1,0056	1,0179	0,9984	1,0056	1,0086	1,0648	21

Table 4.2.9. Malmquist-Luenberger Productivity Index

Bads: NO_X and CO_2

	1985-1986	1986-1987	1987-1988	1988-1989	1989-1990	1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1985-1998	RANK
AUS	0,9994	INF	INF	INF	0,9425	1,0029	0,9960	1,0240	1,0030	INF	INF	INF	INF	0,9664	27
AUT	1,0140	1,0071	1,0236	1,0216	1,0141	1,0054	1,0041	1,0003	0,9983	1,0117	1,0046	0,9850	1,0118	1,1058	16
BEL	1,0217	1,0175	1,0414	1,0065	1,0011	0,9902	1,0026	0,9928	1,0014	0,9973	0,9921	1,0263	1,0108	1,1051	17
CAN	1,0121	1,0096	1,0093	0,9880	0,9883	0,9643	0,9880	1,0030	1,0186	1,0195	1,0172	1,0092	1,0106	1,0367	23
DNK	1,0116	1,0030	1,0273	1,0167	1,0013	0,9819	1,0322	0,9980	1,0338	1,0169	1,0169	1,0045	1,1061	1,2749	3
FIN	0,9900	1,0239	1,0391	1,0231	0,9972	0,9262	0,9901	1,0007	1,0244	1,0618	0,9932	1,0668	1,0323	1,1732	6
FRA	1,0215	1,0162	1,0386	1,0034	1,0077	0,9834	1,0054	0,9948	1,0298	1,0094	0,9887	1,0291	1,0250	1,1624	8
GER	1,0168	1,0136	1,0224	1,0190	1,0134	1,0003	1,0166	0,9983	1,0265	1,0173	1,0021	1,0170	1,0087	1,1858	4
GRC	1,0209	1,0119	1,0243	1,0160	1,0029	1,0258	0,9904	0,9901	1,0157	1,0217	0,9998	1,0024	1,0001	1,1281	12
HUN	1,0140	1,0224	1,0019	1,0107	0,9946	0,9561	1,0326	1,0358	1,0193	1,0262	0,9812	1,0232	1,0169	1,1402	10
ISL	1,0159	1,0317	0,9791	1,0010	0,9898	INF	0,9761	INF	INF	INF	1,0044	1,0387	1,0061	1,0417	22
IRL	0,9796	1,0229	1,0324	1,0353	1,0488	0,9897	1,0382	1,0327	1,0570	1,0598	1,0231	1,0379	1,0154	1,4397	2
ITA	1,0161	1,0110	1,0220	1,0061	1,0035	0,9987	0,9959	0,9972	1,0153	1,0161	1,0055	0,9997	1,0039	1,0945	19
JPN	1,0346	1,0028	1,0165	1,0389	1,0374	1,0211	1,0091	1,0043	INF	INF	INF	INF	INF	1,1762	5
KOR	1,0257	1,0268	1,0038	0,9824	1,0287	1,0029	0,9580	0,9769	1,0055	1,0072	0,9845	0,9832	0,9359	0,9200	29
LUX	INF	1,0070	INF	INF	INF	INF	INF	INF	1,0245	1,0554	1,0077	INF	INF	1,0972	18
MEX	0,9813	1,0092	1,0208	1,0325	1,0354	1,0191	1,0078	1,0002	1,0134	0,9619	1,0093	1,0128	1,0111	1,1185	13
NLD	1,0201	1,0045	1,0195	0,9965	1,0172	0,9989	1,0032	1,0058	1,0267	1,0198	0,9913	1,0271	1,0153	1,1552	9
NZL	0,9966	0,9969	0,9963	0,9883	0,9971	0,9807	0,9992	1,0394	1,0136	0,9397	0,9769	0,9922	1,0273	0,9422	28
NOR	1,0228	1,0134	1,0599	1,0310	0,9597	1,0157	1,0266	1,0100	1,0315	1,0302	1,0174	1,1508	1,0255	1,4606	1
POL	INF	INF	INF	INF	INF	0,9116	1,1245	INF	INF	INF	INF	1,0038	0,9680	0,9961	26
PRT	1,0209	1,0279	1,0463	0,9882	1,0230	1,0157	0,9849	0,9773	1,0003	0,9814	1,0037	0,9703	0,9642	1,0003	25
ESP	1,0346	1,0353	1,0252	0,9927	0,9943	0,9842	0,9759	0,9847	1,0012	1,0304	1,0072	1,0209	1,0206	1,1098	15
SWE	1,0161	1,0240	1,0058	1,0069	1,0091	0,9792	0,9822	1,0189	1,0089	1,0692	0,9910	1,0305	1,0190	1,1697	7
CHE	1,0038	1,0059	1,0183	1,0275	1,0065	1,0041	1,0069	1,0128	1,0054	1,0018	1,0093	0,9571	1,0682	1,1316	11
TUR	1,0205	1,0109	1,0161	0,9705	1,0525	0,9989	1,0102	1,0142	0,9454	1,0151	1,0146	1,0246	0,9797	1,0710	21
GBR	1,0205	1,0224	1,0139	0,9909	0,9898	0,9761	0,9951	1,0176	1,0228	1,0237	1,0013	1,0247	1,0100	1,1127	14
USA	INF	INF	INF	INF	1,0052	0,9910	1,0154	1,0031	INF	1,0022	0,9994	1,0048	1,0079	1,0292	24
GEOMEAN	1,0120	1,0078	1,0127	1,0074	1,0099	0,9950	1,0078	1,0023	1,0129	1,0072	1,0004	1,0089	1,0063	1,0943	20

Table 4.2.10. Malmquist-Luenberger Productivity Index (Efficiency Change)

Bads: NO_X and CO_2

	1985-1986	1986-1987	1987-1988	1988-1989	1989-1990	1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1985-1998	RANK
AUS	0,9989	INF	INF	INF	0,9417	1,0212	1,0312	1,0083	1,0000	INF	INF	INF	INF	0,9988	19
AUT	1,0086	1,0046	1,0247	1,0107	1,0146	1,0070	1,0161	1,0188	0,9967	0,9944	1,0060	0,9883	1,0032	1,0972	7
BEL	1,0047	1,0081	1,0060	1,0000	1,0000	0,9902	1,0046	1,0005	0,9963	0,9437	0,9917	1,0204	0,9969	0,9618	25
CAN	1,0094	1,0009	1,0043	0,9774	0,9869	0,9645	0,9950	1,0094	1,0096	0,9787	1,0166	0,9990	1,0029	0,9542	26
DNK	1,0065	0,9970	1,0176	1,0084	1,0011	0,9819	1,0343	1,0131	1,0260	0,9700	1,0165	0,9932	1,0821	1,1532	4
FIN	0,9900	1,0211	1,0432	1,0109	0,9989	0,9272	1,0132	1,0230	1,0223	1,0506	0,9903	1,0593	1,0179	1,1737	3
FRA	1,0167	1,0118	1,0384	0,9935	1,0051	0,9856	1,0124	1,0194	1,0283	0,9942	0,9907	1,0157	1,0000	1,1162	6
GER	1,0077	1,0082	1,0103	1,0088	1,0132	1,0033	1,0332	1,0077	1,0211	0,9998	1,0025	1,0169	0,9933	1,1329	5
GRC	1,0132	1,0010	1,0046	1,0136	1,0028	1,0341	0,9938	0,9962	1,0062	0,9929	0,9986	0,9787	0,9964	1,0315	9
HUN	0,9882	1,0089	0,9852	1,0052	0,9907	0,9604	1,0409	1,0290	1,0145	1,0131	0,9923	1,0007	1,0025	1,0295	11
ISL	1,0000	1,0000	0,9790	0,9999	1,0099	INF	0,9764	INF	INF	INF	1,0000	1,0000	1,0000	0,9653	23
IRL	0,9674	1,0149	1,0137	1,0318	1,0477	0,9956	1,0412	1,0406	1,0465	1,0375	1,0000	1,0000	1,0000	1,2601	1
ITA	1,0110	1,0056	1,0154	0,9955	1,0028	0,9987	1,0090	1,0053	1,0031	1,0000	1,0000	0,9968	0,9869	1,0302	10
JPN	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	INF	INF	INF	INF	INF	1,0000	16
KOR	1,0001	1,0236	0,9999	0,9814	1,0294	1,0042	0,9648	0,9894	1,0039	0,9877	0,9854	0,9811	0,9286	0,8824	27
LUX	INF	1,0000	INF	INF	INF	INF	INF	INF	1,0000	1,0000	1,0000	INF	INF	1,0000	16
MEX	0,9690	0,9717	1,0061	1,0307	1,0319	1,0382	1,0109	0,9932	1,0065	0,9472	1,0216	0,9845	1,0048	1,0119	14
NLD	1,0154	0,9993	1,0137	0,9873	1,0165	0,9989	1,0068	1,0202	1,0175	0,9607	0,9914	1,0133	0,9962	1,0361	8
NZL	0,9933	0,9874	0,9812	0,9855	0,9937	0,9853	1,0019	1,0497	1,0075	0,9039	0,9779	0,9810	1,0221	0,8720	29
NOR	0,9891	1,0027	1,0240	1,0008	0,9610	1,0150	1,0514	1,0227	1,0230	0,9730	1,0177	1,1349	1,0000	1,2255	2
POL	INF	INF	INF	INF	INF	0,9157	1,0921	INF	INF	INF	INF	1,0000	0,9682	0,9682	22
PRT	1,0000	1,0000	1,0000	0,9883	1,0118	1,0000	0,9853	0,9804	1,0237	0,9616	1,0085	0,9568	0,9596	0,8805	28
ESP	1,0226	1,0222	1,0086	0,9888	0,9906	0,9864	0,9772	1,0025	0,9871	0,9650	1,0066	1,0064	0,9991	0,9621	24
SWE	1,0158	1,0102	1,0000	1,0000	1,0000	0,9796	0,9829	1,0386	1,0000	1,0000	0,9910	1,0091	1,0000	1,0262	12
CHE	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	0,9571	1,0448	1,0000	18
TUR	1,0000	1,0000	1,0000	0,9706	1,0303	0,9999	1,0001	1,0000	0,9453	1,0127	1,0446	1,0000	0,9795	0,9795	20
GBR	1,0000	1,0000	1,0000	0,9906	0,9894	0,9857	1,0026	1,0218	1,0103	0,9964	0,9840	1,0014	0,9879	0,9699	21
USA	INF	INF	INF	INF	1,0000	0,9911	1,0090	1,0000	INF	1,0000	0,9991	1,0009	1,0000	1,0000	15
GEOMEAN	1,0025	1,0022	1,0053	0,9986	1,0018	0,9940	1,0082	1,0044	1,0080	0,9942	1,0001	1,0020	0,9961	1,0174	13

Table 4.2.11. Malmquist-Luenberger Productivity Index (Technical Change)

Bads: NO_X and CO_2

	1985-1986	1986-1987	1987-1988	1988-1989	1989-1990	1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1985-1998	RANK
AUS	1,0005	INF	INF	INF	1,0008	0,9821	0,9658	1,0155	1,0030	INF	INF	INF	INF	0,9674	29
AUT	1,0054	1,0026	0,9989	1,0109	0,9996	0,9984	0,9882	0,9819	1,0016	1,0174	0,9986	0,9967	1,0086	1,0083	27
BEL	1,0169	1,0093	1,0352	1,0065	1,0011	1,0000	0,9980	0,9923	1,0052	1,0568	1,0005	1,0057	1,0140	1,1491	4
CAN	1,0027	1,0087	1,0049	1,0108	1,0014	0,9999	0,9930	0,9937	1,0090	1,0417	1,0006	1,0102	1,0076	1,0866	17
DNK	1,0051	1,0061	1,0095	1,0082	1,0001	1,0000	0,9980	0,9851	1,0075	1,0483	1,0004	1,0114	1,0222	1,1054	13
FIN	1,0000	1,0028	0,9961	1,0120	0,9983	0,9989	0,9773	0,9783	1,0020	1,0107	1,0029	1,0071	1,0141	0,9997	28
FRA	1,0047	1,0043	1,0002	1,0100	1,0027	0,9978	0,9931	0,9759	1,0015	1,0153	0,9980	1,0132	1,0250	1,0416	24
GER	1,0091	1,0053	1,0120	1,0102	1,0002	0,9971	0,9839	0,9907	1,0053	1,0175	0,9996	1,0001	1,0155	1,0469	22
GRC	1,0076	1,0109	1,0196	1,0024	1,0001	0,9920	0,9966	0,9938	1,0094	1,0290	1,0012	1,0242	1,0037	1,0935	15
HUN	1,0261	1,0134	1,0169	1,0055	1,0039	0,9955	0,9920	1,0067	1,0048	1,0130	0,9889	1,0225	1,0143	1,1078	11
ISL	1,0159	1,0317	1,0001	1,0010	0,9801	INF	0,9996	INF	INF	INF	1,0044	1,0387	1,0061	1,0790	19
IRL	1,0127	1,0078	1,0185	1,0035	1,0010	0,9941	0,9971	0,9923	1,0099	1,0215	1,0231	1,0379	1,0154	1,1424	6
ITA	1,0050	1,0054	1,0064	1,0107	1,0007	1,0000	0,9870	0,9919	1,0122	1,0161	1,0055	1,0029	1,0173	1,0624	21
JPN	1,0346	1,0028	1,0165	1,0389	1,0374	1,0211	1,0091	1,0043	INF	INF	INF	INF	INF	1,1762	2
KOR	1,0257	1,0032	1,0039	1,0010	0,9993	0,9987	0,9929	0,9873	1,0017	1,0197	0,9991	1,0022	1,0079	1,0428	23
LUX	INF	1,0070	INF	INF	INF	INF	INF	INF	1,0245	1,0554	1,0077	INF	INF	1,0972	14
MEX	1,0127	1,0386	1,0146	1,0018	1,0035	0,9816	0,9969	1,0071	1,0069	1,0155	0,9880	1,0288	1,0063	1,1058	12
NLD	1,0046	1,0051	1,0057	1,0093	1,0007	1,0000	0,9964	0,9859	1,0090	1,0615	1,0000	1,0136	1,0192	1,1148	10
NZL	1,0033	1,0096	1,0154	1,0029	1,0035	0,9954	0,9973	0,9902	1,0060	1,0396	0,9989	1,0114	1,0050	1,0805	18
NOR	1,0341	1,0106	1,0350	1,0302	0,9987	1,0007	0,9764	0,9876	1,0084	1,0588	0,9997	1,0140	1,0255	1,1919	1
POL	INF	INF	INF	INF	INF	0,9956	1,0297	INF	INF	INF	INF	1,0038	0,9998	1,0289	26
PRT	1,0209	1,0279	1,0463	0,9998	1,0111	1,0157	0,9996	0,9968	0,9771	1,0207	0,9953	1,0142	1,0048	1,1363	8
ESP	1,0118	1,0128	1,0165	1,0040	1,0038	0,9978	0,9986	0,9822	1,0143	1,0678	1,0006	1,0144	1,0216	1,1538	3
SWE	1,0003	1,0136	1,0058	1,0069	1,0091	0,9997	0,9993	0,9810	1,0089	1,0692	1,0000	1,0212	1,0190	1,1399	7
CHE	1,0038	1,0059	1,0183	1,0275	1,0065	1,0041	1,0069	1,0128	1,0054	1,0018	1,0093	1,0000	1,0224	1,1317	9
TUR	1,0205	1,0109	1,0161	0,9999	1,0216	0,9990	1,0100	1,0142	1,0001	1,0024	0,9713	1,0246	1,0002	1,0934	16
GBR	1,0205	1,0224	1,0139	1,0003	1,0004	0,9903	0,9925	0,9958	1,0124	1,0274	1,0176	1,0233	1,0223	1,1472	5
USA	INF	INF	INF	INF	1,0052	0,9999	1,0063	1,0031	INF	1,0022	1,0003	1,0039	1,0079	1,0291	25
GEOMEAN	1,0096	1,0056	1,0073	1,0088	1,0081	1,0010	1,0000	0,9979	1,0049	1,0132	1,0003	1,0069	1,0102	1,0762	20

Table 4.2.12. Malmquist-Luenberger Productivity Index

Bads: NO_X and Organic Water Pollutant

	1985-1986	1986-1987	1987-1988	1988-1989	1989-1990	1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1985-1998	RANK
AUS	1,0027	1,0296	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	1,0324	23
AUT	1,0177	1,0156	1,0281	1,0255	1,0222	1,0188	1,0168	1,0248	1,0092	1,0328	1,0166	0,9995	1,0261	1,2851	4
BEL	1,0201	1,0140	1,0269	1,0075	1,0124	1,0024	1,0044	0,9912	1,0139	1,0037	0,9961	1,0079	1,0024	1,1073	19
CAN	1,0029	1,0168	1,0206	1,0119	0,9992	0,9865	1,0014	1,0178	1,0223	1,0144	1,0089	1,0197	1,0265	1,1587	14
DNK	1,0026	1,0065	1,0176	1,0080	0,9521	1,0048	1,0236	1,0092	1,0345	0,9968	0,9908	1,0215	INF	1,0676	21
FIN	1,0129	1,0197	1,0264	1,0305	1,0127	0,9707	0,9991	1,0086	1,0231	1,0406	1,0197	1,0426	1,0455	1,2806	5
FRA	1,0160	1,0132	1,0295	1,0032	1,0301	1,0005	1,0126	1,0047	1,0064	1,0162	1,0107	1,0114	1,0166	1,1847	13
GER	1,0140	1,0200	1,0268	1,0225	1,0239	1,0131	1,0146	1,0049	1,0397	1,0187	1,0100	1,0177	1,0143	1,2682	6
GRC	1,0153	1,0096	1,0260	1,0220	1,0020	1,0189	1,0016	0,9914	1,0118	1,0189	1,0038	1,0099	1,0038	1,1431	15
HUN	INF	INF	0,9819	INF	0,9490	0,8973	1,0363	0,9883	INF	INF	0,9744	1,0054	0,9841	0,8256	27
ISL	INF	INF	0,7445	1,0079	1,0055	1,0000	0,9887	1,0177	INF	INF	0,9358	0,9900	0,8936	0,6285	29
IRL	0,9815	1,0080	1,0267	1,0253	1,0498	1,0011	1,0221	1,0368	1,0652	1,0846	1,0189	1,0347	1,0130	1,4311	1
ITA	1,0155	1,0074	1,0369	1,0121	1,0139	1,0049	0,9914	1,0044	1,0268	1,0361	1,0070	1,0123	1,0119	1,1953	9
JPN	INF	1,0068	1,0252	1,0404	INF	INF	1,0041	1,0023	1,0115	1,0030	1,0204	1,0047	INF	1,1241	17
KOR	1,0116	1,0172	1,0063	0,9997	1,0558	1,0428	0,9786	0,9937	1,0282	1,0336	1,0192	0,9919	0,9553	1,1375	16
LUX	INF	1,0090	INF	INF	1,0779	INF	INF	INF	INF	1,0200	1,0120	1,0643	INF	1,1949	10
MEX	0,9812	1,0375	1,0204	1,0160	1,0323	1,0328	1,0300	1,0658	1,0635	1,0082	0,9836	1,0313	1,0315	1,3858	2
NLD	1,0135	0,9995	1,0225	1,0235	1,0173	1,0059	1,0102	1,0188	1,0275	1,0276	1,0109	1,0291	1,0262	1,2585	7
NZL	1,0067	1,0146	1,0078	0,9992	1,0021	0,9986	0,9975	1,0363	1,0088	0,9443	0,9939	0,9963	1,0221	1,0258	24
NOR	1,0109	1,0125	1,0036	1,0098	1,0128	1,0291	1,0325	1,0146	1,0270	1,0228	1,0309	1,0473	1,0157	1,3046	3
POL	INF	INF	INF	INF	INF	0,9524	1,0908	INF	INF	INF	INF	1,0058	0,9663	1,0097	26
PRT	0,9408	0,9983	1,0283	0,9739	1,0536	0,9783	0,9369	0,9397	0,9868	0,9833	0,9939	0,9871	0,9733	0,7908	28
ESP	1,0227	1,0285	1,0210	1,0034	0,9910	0,9955	0,9946	0,9665	1,0119	1,0338	0,9979	1,0033	1,0022	1,0727	20
SWE	1,0098	1,0132	1,0090	1,0090	1,0257	0,9833	1,0104	1,0159	1,0170	1,0706	0,9982	1,0191	1,0198	1,2180	8
CHE	1,0060	1,0047	1,0382	1,0613	INF	INF	0,9948	1,0037	INF	INF	INF	INF	INF	1,1120	18
TUR	1,0222	1,0095	0,9864	0,9779	1,0545	1,0045	1,0038	1,0153	0,9461	1,0235	1,0159	1,0147	0,9746	1,0454	22
GBR	1,0244	1,0236	1,0004	0,9613	0,9610	0,9754	0,9937	1,0149	1,0208	1,0194	1,0013	1,0220	1,0028	1,0180	25
USA	1,0125	1,0156	1,0375	1,0128	1,0036	1,0090	1,0165	1,0069	1,0177	1,0046	1,0106	1,0133	1,0177	1,1932	11
GEOMEAN	1,0101	1,0150	1,0263	1,0126	1,0074	1,0038	1,0094	1,0069	1,0403	1,0123	1,0093	1,0125	1,0100	1,1903	12

Table 4.2.13. Malmquist-Luenberger Productivity Index (Efficiency Change)

Bads: NO_X and Organic Water Pollutant

	1985-1986	1986-1987	1987-1988	1988-1989	1989-1990	1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1985-1998	RANK
AUS	1,0000	1,0000	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	1,0000	11
AUT	1,0072	1,0113	0,9943	0,9982	1,0159	1,0167	1,0159	1,0098	0,9886	1,0149	0,9997	0,9751	0,9965	1,0440	4
BEL	0,9953	1,0052	0,9865	0,9812	1,0082	1,0012	0,9931	0,9648	0,9952	0,9919	0,9919	0,9865	0,9852	0,8913	26
CAN	0,9860	1,0032	0,9965	0,9892	0,9906	0,9813	0,9985	1,0139	1,0119	0,9943	0,9956	1,0039	1,0082	0,9729	20
DNK	0,9875	0,9990	0,9930	0,9941	0,9469	1,0029	1,0122	0,9921	1,0325	0,9981	0,9934	1,0097	ÍNF	0,9599	23
FIN	1,0005	1,0075	0,9903	1,0065	1,0030	0,9655	0,9955	1,0047	1,0020	1,0199	1,0147	1,0225	1,0285	1,0612	3
FRA	1,0063	1,0094	0,9952	0,9791	1,0225	0,9967	1,0086	0,9902	0,9844	0,9945	0,9979	0,9820	0,9866	0,9535	24
GER	1,0066	1,0188	1,0045	1,0114	1,0177	1,0119	1,0139	0,9946	1,0180	1,0011	0,9946	0,9899	0,9855	1,0699	2
GRC	1,0041	1,0034	1,0073	1,0080	0,9902	1,0117	0,9913	0,9783	0,9921	1,0172	1,0027	1,0046	0,9898	1,0000	16
HUN	INF	INF	0,9808	INF	0,9505	0,8973	1,1725	1,0000	INF	INF	0,9752	1,0049	0,9999	0,9611	22
ISL	INF	INF	0,7320	0,9935	1,0045	0,9988	0,9972	1,0241	INF	INF	0,9381	0,9968	0,9259	0,6451	29
IRL	0,9698	1,0031	0,9997	1,0056	1,0411	0,9963	1,0090	1,0303	1,0632	1,0943	1,0000	1,0000	1,0000	1,2269	1
ITA	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	0,9903	1,0027	1,0071	1,0000	1,0000	1,0000	1,0000	1,0000	10
JPN	INF	1,0000	1,0000	1,0000	INF	INF	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	INF	1,0000	11
KOR	0,9961	1,0116	0,9813	0,9834	1,0510	1,0415	0,9736	0,9848	1,0087	1,0179	1,0095	0,9831	0,9358	0,9732	19
LUX	INF	1,0000	INF	INF	1,0000	INF	INF	INF	INF	1,0000	1,0000	1,0000	INF	1,0000	11
MEX	0,9837	1,0166	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	0,9831	1,0172	1,0000	1,0000	9
NLD	0,9972	0,9842	0,9928	1,0092	1,0120	1,0050	1,0032	1,0030	1,0031	1,0052	1,0026	1,0031	0,9959	1,0163	7
NZL	0,9782	1,0046	0,9706	0,9721	0,9957	0,9935	1,0078	1,0385	1,0095	0,9487	0,9931	0,9799	1,0037	0,8980	25
NOR	0,9971	0,9973	0,9623	0,9822	1,0016	1,0273	1,0261	1,0018	1,0106	0,9889	1,0168	1,0196	0,9930	1,0228	6
POL	INF	INF	INF	INF	INF	0,9524	1,0500	INF	INF	INF	INF	1,0000	0,9664	0,9664	21
PRT	0,9277	0,9912	1,0148	0,9702	1,0534	0,9847	0,9862	0,9527	0,9767	0,9882	0,9779	0,9631	0,9679	0,7763	28
ESP	1,0009	1,0199	0,9853	0,9792	0,9823	0,9909	0,9837	0,9459	0,9920	1,0284	0,9978	0,9931	0,9878	0,8907	27
SWE	0,9879	1,0033	0,9798	0,9857	1,0184	0,9793	1,0057	0,9902	1,0008	1,0705	1,0005	1,0064	1,0037	1,0294	5
CHE	1,0000	1,0000	1,0000	1,0000	INF	INF	1,0000	1,0000	INF	INF	INF	INF	INF	1,0000	11
TUR	1,0000	1,0000	0,9862	0,9769	1,0379	1,0000	1,0000	1,0000	0,9436	1,0230	1,0360	1,0000	0,9742	0,9742	18
GBR	0,9986	1,0199	0,9969	0,9585	0,9594	0,9771	1,0095	1,0150	1,0208	1,0288	0,9995	1,0067	0,9926	0,9805	17
USA	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	11
GEOMEAN	0,9990	1,0046	0,9979	0,9951	1,0018	0,9986	1,0019	0,9978	1,0100	1,0038	0,9995	0,9983	0,9954	1,0036	8

Table 4.2.14. Malmquist-Luenberger Productivity Index (Technical Change)

Bads: NO_X and Organic Water Pollutant

	1985-1986	1986-1987	1987-1988	1988-1989	1989-1990	1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1985-1998	RANK
AUS	1,0027	1,0296	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	1,0324	26
AUT	1,0104	1,0042	1,0341	1,0274	1,0062	1,002	1,0009	1,0148	1,0209	1,0177	1,017	1,025	1,0297	1,2311	6
BEL	1,025	1,0087	1,041	1,0268	1,0042	1,0012	1,0114	1,0274	1,0188	1,0118	1,0042	1,0217	1,0174	1,2424	4
CAN	1,0172	1,0136	1,0242	1,0229	1,0087	1,0053	1,003	1,0038	1,0103	1,0201	1,0133	1,0157	1,0182	1,1910	13
DNK	1,0153	1,0075	1,0247	1,014	1,0056	1,002	1,0112	1,0172	1,002	0,9986	0,9974	1,0118	INF	1,1123	21
FIN	1,0124	1,0121	1,0364	1,0239	1,0097	1,0053	1,0036	1,0039	1,021	1,0203	1,0049	1,0197	1,0165	1,2066	7
FRA	1,0095	1,0037	1,0345	1,0246	1,0075	1,0038	1,004	1,0147	1,0223	1,0218	1,0128	1,03	1,0304	1,2424	3
GER	1,0073	1,0011	1,0221	1,011	1,0061	1,0012	1,0006	1,0104	1,0214	1,0176	1,0155	1,028	1,0293	1,1852	14
GRC	1,0112	1,0061	1,0185	1,0138	1,012	1,0071	1,0104	1,0134	1,0199	1,0016	1,0012	1,0052	1,0142	1,1431	18
HUN	INF	INF	1,0012	INF	0,9984	1	0,8839	0,9883	INF	INF	0,9992	1,0005	0,9841	0,8591	29
ISL	INF	INF	1,0171	1,0144	1,0011	1,0013	0,9915	0,9938	INF	INF	0,9975	0,9932	0,9651	0,9744	28
IRL	1,012	1,0049	1,027	1,0196	1,0083	1,0048	1,013	1,0063	1,0018	0,9911	1,0189	1,0347	1,013	1,1662	17
ITA	1,0155	1,0074	1,0369	1,0121	1,0139	1,0049	1,0011	1,0018	1,0195	1,0361	1,007	1,0123	1,0119	1,1953	9
JPN	INF	1,0068	1,0252	1,0404	INF	INF	1,0041	1,0023	1,0115	1,003	1,0204	1,0047	INF	1,1241	20
KOR	1,0155	1,0055	1,0255	1,0166	1,0046	1,0013	1,0052	1,009	1,0194	1,0154	1,0096	1,009	1,0209	1,1691	16
LUX	INF	1,009	INF	INF	1,0779	INF	INF	INF	INF	1,02	1,012	1,0643	INF	1,1949	10
MEX	0,9975	1,0206	1,0204	1,016	1,0323	1,0328	1,03	1,0658	1,0635	1,0082	1,0005	1,0138	1,0315	1,3858	1
NLD	1,0164	1,0156	1,0299	1,0141	1,0052	1,0009	1,007	1,0157	1,0243	1,0222	1,0083	1,0259	1,0304	1,2381	5
NZL	1,0292	1,0099	1,0382	1,0279	1,0064	1,0052	0,9898	0,9978	0,9993	0,9954	1,0009	1,0167	1,0183	1,1423	19
NOR	1,0138	1,0152	1,0429	1,0281	1,0112	1,0018	1,0063	1,0128	1,0162	1,0342	1,0139	1,0272	1,0229	1,2756	2
POL	INF	INF	INF	INF	INF	1	1,0388	INF	INF	INF	INF	1,0058	0,9999	1,0447	24
PRT	1,0141	1,0071	1,0133	1,0038	1,0001	0,9936	0,9501	0,9863	1,0103	0,9951	1,0163	1,0249	1,0056	1,0186	27
ESP	1,0218	1,0084	1,0362	1,0248	1,0088	1,0046	1,0111	1,0218	1,02	1,0053	1,0002	1,0103	1,0146	1,2044	8
SWE	1,0221	1,0098	1,0299	1,0236	1,0071	1,0042	1,0047	1,026	1,0162	1,0001	0,9976	1,0126	1,016	1,1832	15
CHE	1,006	1,0047	1,0382	1,0613	INF	INF	0,9948	1,0037	INF	INF	INF	INF	INF	1,1120	22
TUR	1,0222	1,0095	1,0002	1,001	1,0159	1,0045	1,0038	1,0153	1,0026	1,0006	0,9806	1,0147	1,0005	1,0731	23
GBR	1,0259	1,0036	1,0036	1,003	1,0017	0,9982	0,9844	0,9999	1	0,9908	1,0018	1,0151	1,0103	1,0383	25
USA	1,0125	1,0156	1,0375	1,0128	1,0036	1,009	1,0165	1,0069	1,0177	1,0046	1,0106	1,0133	1,0177	1,1932	12
GEOMEAN	1,0111	1,0103	1,0285	1,0176	1,0056	1,0053	1,0075	1,0091	1,0360	1,0084	1,0099	1,0142	1,0156	1,1941	11

Table 4.2.15. Malmquist-Luenberger Productivity Index

Bads: CO2 and Organic Water Pollutant

	1985-1986	1986-1987	1987-1988	1988-1989	1989-1990	1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1985-1998	RANK
AUS	1,0036	1,0149	1,0161	0,9989	0,9778	1,0052	1,0212	1,0218	1,0258	1,0481	1,0358	0,9914	1,0190	1,1929	6
AUT	1,0169	1,0063	1,0287	1,0118	0,9980	1,0124	1,0235	1,0066	1,0095	1,0082	1,0115	1,0073	1,0204	1,1732	8
BEL	1,0210	1,0214	1,0475	1,0066	1,0017	0,9914	1,0043	0,9936	1,0004	0,9987	0,9905	1,0251	1,0107	1,1172	13
CAN	1,0078	1,0066	1,0101	1,0006	0,9961	0,9746	0,9937	1,0145	1,0228	1,0147	1,0088	1,0142	1,0147	1,0812	18
DNK	1,0170	1,0029	1,0278	1,0170	0,9905	0,9816	1,0349	0,9996	1,0381	1,0142	1,0050	1,0139	0,9705	1,1165	14
FIN	0,9871	1,0232	1,0374	1,0235	1,0161	0,9724	1,0193	0,9950	0,9941	1,0582	0,9957	1,0618	1,0351	1,2371	3
FRA	1,0282	1,0220	1,0526	0,9928	1,0098	0,9858	1,0253	1,0050	1,0358	1,0081	0,9897	1,0309	1,0243	1,2292	4
GER	1,0160	1,0158	1,0198	1,0142	1,0093	0,9977	1,0101	0,9898	1,0233	1,0137	0,9951	1,0134	1,0133	1,1391	11
GRC	1,0222	1,0085	1,0240	1,0164	1,0045	1,0306	0,9867	0,9876	1,0139	1,0209	1,0030	1,0095	1,0081	1,1436	10
HUN	INF	INF	INF	1,0056	0,9990	0,8581	1,0291	1,0308	INF	INF	0,9703	INF	0,9904	0,8788	29
ISL	INF	INF	0,9717	0,9968	0,9861	1,0109	0,9366	1,0038	1,0397	INF	0,9875	1,0278	0,9840	0,9426	27
IRL	0,9807	1,0265	1,0349	1,0416	1,0395	0,9894	1,0422	1,0297	1,0519	1,0530	1,0361	1,0360	1,0166	1,4477	2
ITA	1,0242	1,0088	1,0337	1,0098	1,0117	1,0051	0,9999	1,0029	1,0175	1,0249	1,0059	1,0089	1,0085	1,1738	7
JPN	1,0114	1,0225	0,9955	1,0114	1,0010	1,0098	1,0020	1,0094	0,9953	1,0030	1,0160	0,9998	0,9795	1,0573	21
KOR	1,0265	1,0213	1,0064	0,9995	1,0086	1,0076	0,9891	0,9904	1,0087	1,0063	1,0093	1,0105	0,9532	1,0360	23
LUX	INF	1,0075	INF	INF	INF	INF	INF	INF	INF	INF	1,0160	INF	INF	1,0236	24
MEX	0,9993	1,0143	1,0172	1,0177	1,0407	1,0637	INF	INF	INF	0,9911	INF	INF	INF	1,1512	9
NLD	1,0216	1,0036	1,0212	1,0034	1,0177	1,0017	1,0054	1,0034	1,0224	1,0167	0,9894	1,0157	1,0078	1,1374	12
NZL	0,9930	0,9944	0,9927	0,9867	0,9932	0,9770	1,0003	1,0395	1,0125	0,9340	0,9794	1,0023	1,0219	0,9258	28
NOR	1,0193	1,0125	1,0847	1,0321	0,9655	1,0180	1,0277	1,0088	1,0278	1,0235	1,0308	1,1102	1,0226	1,4494	1
POL	INF	INF	INF	INF	0,9135	1,0422	1,0905	INF	INF	INF	INF	1,0131	0,9674	1,0175	25
PRT	1,0512	1,0202	1,0282	0,9831	1,0663	1,0081	0,9822	0,9798	0,9956	0,9727	1,0056	0,9648	1,0142	1,0686	20
ESP	1,0403	1,0310	1,0214	0,9990	1,0009	0,9895	0,9824	0,9785	0,9990	1,0319	1,0015	1,0104	1,0184	1,1069	15
SWE	1,0150	1,0209	1,0081	1,0081	1,0171	0,9780	0,9875	1,0334	1,0159	1,0685	0,9925	1,0263	1,0214	1,2072	5
CHE	0,9994	1,0019	1,0196	1,0383	0,9930	1,0017	1,0076	1,0118	0,9945	1,0416	0,9899	0,9356	1,0378	1,0703	19
TUR	1,0214	1,0142	1,0160	0,9739	1,0482	1,0051	1,0067	1,0173	0,9522	1,0158	1,0210	1,0223	0,9876	1,1027	16
GBR	1,0228	1,0243	1,0108	0,9913	0,9912	0,9758	0,9956	1,0172	1,0218	1,0188	0,9911	1,0042	0,9890	1,0536	22
USA	INF	INF	INF	INF	1,0044	INF	INF	INF	INF	1,0040	INF	INF	INF	1,0084	26
GEOMEAN	1,0107	1,0109	1,0112	1,0036	1,0047	1,0004	1,0036	1,0027	1,0154	1,0098	1,0026	1,0061	1,0001	1,0848	17

Table 4.2.16. Malmquist-Luenberger Productivity Index (Efficiency Change)

Bads: CO2 and Organic Water Pollutant

	1985-1986	1986-1987	1987-1988	1988-1989	1989-1990	1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1985-1998	RANK
AUS	0,9864	1,0047	1,0000	0,9872	0,9739	1,0050	1,0174	1,0234	1,0130	1,0325	1,0172	0,9750	0,9971	1,0312	6
AUT	1,0039	1,0059	1,0169	1,0032	0,9934	1,0115	1,0226	1,0013	0,9930	0,9999	1,0069	0,9956	1,0034	1,0586	5
BEL	1,0143	1,0123	1,0275	1,0000	1,0000	0,9914	1,0054	0,9983	0,9988	0,9433	0,9898	1,0187	0,9939	0,9912	17
CAN	0,9980	0,9989	0,9942	0,9862	0,9867	0,9698	0,9922	1,0114	1,0120	0,9906	1,0033	1,0057	1,0036	0,9528	24
DNK	1,0036	0,9920	1,0114	1,0128	0,9852	0,9816	1,0356	1,0187	1,0394	0,9638	1,0053	1,0074	0,9710	1,0250	7
FIN	0,9743	1,0136	1,0209	1,0105	1,0094	0,9692	1,0167	0,9871	0,9816	1,0434	0,9940	1,0540	1,0179	1,0925	3
FRA	1,0144	1,0218	1,0399	0,9818	1,0086	0,9851	1,0216	0,9952	1,0172	0,9997	0,9877	1,0128	1,0000	1,0874	4
GER	0,9949	1,0032	0,9958	1,0107	1,0062	0,9977	1,0102	0,9938	1,0102	0,9911	0,9916	1,0109	1,0037	1,0198	9
GRC	1,0056	0,9992	1,0068	1,0125	0,9967	1,0265	0,9834	0,9917	0,9992	0,9989	1,0020	1,0043	0,9915	1,0178	10
HUN	INF	INF	INF	1,0000	1,0000	0,8583	1,0545	1,1048	INF	INF	0,9692	INF	0,9897	0,9591	23
ISL	INF	INF	0,9714	0,9943	1,0082	1,0270	0,9447	1,0129	1,0451	INF	0,9823	1,0180	0,9862	0,9863	20
IRL	0,9687	1,0159	1,0191	1,0386	1,0341	0,9888	1,0390	1,0386	1,0447	1,0497	1,0000	1,0000	1,0000	1,2604	1
ITA	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	13
JPN	0,9948	1,0220	0,9843	1,0048	1,0009	1,0089	0,9991	0,9997	0,9798	0,9856	1,0111	0,9916	0,9631	0,9457	27
KOR	1,0222	1,0074	0,9836	0,9988	1,0002	1,0066	0,9887	0,9867	0,9964	0,9994	1,0021	1,0099	0,9486	0,9499	26
LUX	INF	1,0000	INF	INF	INF	INF	INF	INF	INF	INF	1,0000	INF	INF	1,0000	13
MEX	0,9979	1,0021	1,0000	1,0000	1,0000	1,0000	INF	INF	INF	0,9907	INF	INF	INF	0,9907	18
NLD	1,0070	0,9951	1,0010	0,9967	1,0143	1,0017	1,0043	1,0105	1,0065	0,9886	0,9881	1,0091	0,9982	1,0209	8
NZL	0,9910	0,9978	0,9833	0,9850	0,9919	0,9783	1,0015	1,0510	1,0098	0,9002	0,9748	0,9902	1,0027	0,8606	29
NOR	0,9988	0,9953	1,0626	1,0186	0,9604	1,0088	1,0242	0,9976	1,0107	0,9891	1,0167	1,0977	1,0062	1,1957	2
POL	INF	INF	INF	INF	0,9144	1,0422	1,0493	INF	INF	INF	INF	1,0000	0,9674	0,9674	22
PRT	1,0000	1,0000	1,0000	0,9827	1,0176	1,0000	0,9827	0,9837	1,0260	0,9719	1,0126	0,9674	1,0590	1,0000	16
ESP	1,0282	1,0138	1,0036	0,9961	0,9939	0,9885	0,9809	0,9935	0,9780	0,9791	1,0011	0,9978	0,9960	0,9505	25
SWE	1,0039	1,0000	1,0000	1,0000	1,0000	0,9780	0,9874	1,0355	1,0000	1,0000	0,9924	1,0076	1,0000	1,0038	11
CHE	0,9991	1,0009	1,0000	1,0000	0,9930	1,0016	1,0054	1,0000	0,9944	1,0056	0,9922	0,9378	1,0748	1,0000	12
TUR	1,0000	1,0000	1,0000	0,9734	1,0273	1,0000	1,0000	1,0000	0,9510	1,0118	1,0393	1,0000	0,9859	0,9859	21
GBR	1,0000	1,0000	1,0000	0,9910	0,9903	0,9837	0,9967	1,0220	1,0158	1,0012	0,9701	0,9834	0,9805	0,9355	28
USA	INF	INF	INF	INF	1,0000	INF	INF	INF	INF	1,0000	INF	INF	INF	1,0000	13
GEOMEAN	1,0006	1,0052	1,0003	0,9989	0,9989	0,9978	1,0023	1,0016	0,9958	0,9958	0,9994	0,9999	0,9929	0,9894	19

Table 4.2.17. Malmquist-Luenberger Productivity Index (Technical Change)

Bads: CO_2 and Organic Water Pollutant

	1985-1986	1986-1987	1987-1988	1988-1989	1989-1990	1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1985-1998	RANK
AUS	1,0174	1,0102	1,0160	1,0118	1,0040	1,0002	1,0038	0,9984	1,0127	1,0151	1,0182	1,0168	1,0220	1,1566	6
AUT	1,0129	1,0004	1,0116	1,0086	1,0047	1,0009	1,0009	1,0053	1,0166	1,0084	1,0046	1,0118	1,0170	1,1086	18
BEL	1,0066	1,0090	1,0194	1,0066	1,0017	1,0000	0,9989	0,9952	1,0016	1,0587	1,0007	1,0063	1,0169	1,1269	11
CAN	1,0098	1,0077	1,0160	1,0146	1,0095	1,0049	1,0015	1,0031	1,0107	1,0244	1,0054	1,0084	1,0111	1,1346	8
DNK	1,0134	1,0110	1,0162	1,0041	1,0055	1,0000	0,9993	0,9813	0,9988	1,0523	0,9998	1,0065	0,9995	1,0897	21
FIN	1,0132	1,0094	1,0162	1,0128	1,0066	1,0033	1,0026	1,0080	1,0128	1,0141	1,0017	1,0074	1,0169	1,1323	9
FRA	1,0136	1,0002	1,0122	1,0112	1,0012	1,0008	1,0036	1,0099	1,0183	1,0085	1,0020	1,0179	1,0243	1,1306	10
GER	1,0212	1,0126	1,0241	1,0034	1,0031	1,0000	0,9999	0,9960	1,0130	1,0229	1,0036	1,0026	1,0095	1,1173	16
GRC	1,0165	1,0094	1,0170	1,0038	1,0078	1,0041	1,0034	0,9960	1,0147	1,0221	1,0010	1,0052	1,0168	1,1240	13
HUN	INF	INF	INF	1,0056	0,9990	0,9998	0,9759	0,9330	INF	INF	1,0011	INF	1,0007	0,9162	29
ISL	INF	INF	1,0003	1,0024	0,9781	0,9844	0,9914	0,9910	0,9948	INF	1,0053	1,0097	0,9978	0,9557	28
IRL	1,0123	1,0104	1,0155	1,0029	1,0052	1,0006	1,0031	0,9914	1,0068	1,0031	1,0361	1,0360	1,0166	1,1483	7
ITA	1,0242	1,0088	1,0337	1,0098	1,0117	1,0051	0,9999	1,0029	1,0175	1,0249	1,0059	1,0089	1,0085	1,1738	3
JPN	1,0167	1,0005	1,0114	1,0067	1,0002	1,0009	1,0029	1,0097	1,0159	1,0177	1,0048	1,0083	1,0171	1,1186	14
KOR	1,0042	1,0138	1,0232	1,0008	1,0084	1,0010	1,0004	1,0037	1,0123	1,0069	1,0072	1,0007	1,0049	1,0908	20
LUX	INF	1,0075	INF	INF	INF	INF	INF	INF	INF	INF	1,0160	INF	INF	1,0236	26
MEX	1,0014	1,0121	1,0172	1,0177	1,0407	1,0637	INF	INF	INF	1,0004	INF	INF	INF	1,1619	5
NLD	1,0145	1,0086	1,0202	1,0067	1,0033	1,0000	1,0012	0,9930	1,0158	1,0284	1,0013	1,0065	1,0097	1,1143	17
NZL	1,0021	0,9966	1,0095	1,0018	1,0014	0,9987	0,9988	0,9891	1,0026	1,0375	1,0046	1,0123	1,0191	1,0758	22
NOR	1,0206	1,0173	1,0208	1,0132	1,0053	1,0091	1,0035	1,0112	1,0169	1,0348	1,0139	1,0114	1,0162	1,2122	1
POL	INF	INF	INF	INF	0,9990	1,0000	1,0393	INF	INF	INF	INF	1,0131	1,0000	1,0519	25
PRT	1,0512	1,0202	1,0282	1,0004	1,0478	1,0081	0,9995	0,9959	0,9704	1,0009	0,9932	0,9974	0,9576	1,0686	24
ESP	1,0118	1,0170	1,0177	1,0029	1,0071	1,0010	1,0015	0,9849	1,0215	1,0538	1,0004	1,0126	1,0225	1,1644	4
SWE	1,0111	1,0209	1,0081	1,0081	1,0171	1,0000	1,0001	0,9979	1,0159	1,0685	1,0001	1,0185	1,0214	1,2026	2
CHE	1,0003	1,0010	1,0196	1,0383	1,0000	1,0000	1,0022	1,0118	1,0001	1,0359	0,9977	0,9977	0,9656	1,0703	23
TUR	1,0214	1,0142	1,0160	1,0005	1,0203	1,0051	1,0067	1,0173	1,0013	1,0040	0,9824	1,0223	1,0018	1,1186	15
GBR	1,0228	1,0243	1,0108	1,0003	1,0009	0,9920	0,9989	0,9954	1,0059	1,0176	1,0217	1,0211	1,0086	1,1264	12
USA	INF	INF	INF	INF	1,0044	INF	INF	INF	INF	1,0040	INF	INF	INF	1,0084	27
GEOMEAN	1,0101	1,0057	1,0109	1,0047	1,0058	1,0026	1,0013	1,0011	1,0196	1,0141	1,0031	1,0062	1,0072	1,0963	19

APPENDIX C

Table 4.4.2. Environmental Quantity Index

Bads: NO_X and CO_2

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	MEAN
AUS	INF	INF	INF	INF	INF	INF	INF	INF	0,6298	INF	0,6221	0,7751	0,8617	0,7848	0,8159	0,7843	0,7534
AUT	0,1418	0,1430	0,1457	0,1422	0,1398	0,1298	0,1290	0,1335	0,1367	0,1327	0,1275	0,1267	0,1205	0,1169	0,1184	0,1170	0,1313
BEL	0,2489	0,2415	0,2391	0,2363	0,2365	0,2204	0,2293	0,2326	0,2383	0,2462	0,2299	0,2326	0,2291	0,2270	0,2223	0,2209	0,2332
CAN	1,1679	1,1612	1,1269	1,1132	1,1681	1,2114	1,2135	1,1953	1,1307	1,1026	1,1408	1,1805	1,2114	1,1825	1,2066	1,2131	1,1704
DNK	0,1607	0,1637	0,1778	0,1785	0,1781	0,1590	0,1401	0,1546	0,1802	0,1489	0,1554	0,1630	0,1520	0,1643	0,1519	0,0800	0,1568
FIN	0,1338	0,1361	0,1382	0,1559	0,1591	0,1467	0,1525	0,1606	0,1537	0,1276	0,1420	0,1583	0,1527	0,1609	0,1553	0,1530	0,1492
FRA	1,0740	1,0502	1,0403	1,0004	0,9796	0,9179	0,9838	0,9591	0,9912	0,9408	0,9124	0,9503	0,9903	0,9872	0,9653	0,9652	0,9818
GER	2,2027	2,2233	2,2505	2,2821	2,2081	2,0666	2,0535	1,9343	1,8557	1,8071	1,7664	1,5860	1,5030	1,4933	1,3752	1,3643	1,8733
GRC	0,1816	0,1810	0,1720	0,1712	0,1824	0,1884	0,1955	0,2019	0,1943	0,1983	0,2018	0,2103	0,2156	0,2235	0,2259	0,2361	0,1987
HUN	0,1916	0,1941	0,1936	0,1929	0,1898	0,1728	0,1682	0,1584	0,1445	0,1324	0,1309	0,1258	0,1268	0,1310	0,1250	0,1211	0,1562
ISL	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	N/A
IRL	0,0594	0,0595	0,0643	0,0720	0,0767	0,0770	0,0754	0,0752	0,0802	0,0791	0,0787	0,0770	0,0797	0,0794	0,0814	0,0794	0,0747
ITA	0,9975	1,0013	0,9952	0,9881	1,0479	1,0571	1,0788	1,1290	1,1297	1,1101	1,0954	1,0531	1,0896	1,0744	1,0940	1,0938	1,0647
JPN	1,1767	1,2635	1,2181	1,2435	1,3569	1,4322	1,5553	INF	INF	INF	INF	INF	INF	INF	INF	INF	1,3209
KOR	0,4484	0,4592	0,4654	0,4792	0,5047	0,5736	0,6200	0,6062	0,6092	0,7188	0,7782	0,7918	0,7975	0,8619	0,8905	0,9310	0,6585
LUX	0,0072	0,0081	0,0078	0,0085	0,0088	0,0090	0,0101	0,0127	0,0137	0,0143	0,0147	0,0145	0,0126	0,0127	0,0131	0,0125	0,0113
MEX	0,9174	0,8726	0,7941	0,7669	0,8097	0,7733	0,8018	0,8618	0,8685	0,8823	0,8838	0,9146	0,9174	0,9274	0,9346	0,9386	0,8666
NLD	0,3416	0,3530	0,3578	0,3434	0,3515	0,3416	0,3553	0,3638	0,3577	0,3527	0,3439	0,3265	0,3234	0,3374	0,3154	0,3088	0,3421
NZL	0,0561	0,0612	0,0615	0,0707	0,0735	0,0714	0,0741	0,0750	0,0751	0,0733	0,0747	0,0827	0,0866	0,0840	0,0874	0,0855	0,0746
NOR	0,1576	0,1751	0,1849	0,1907	0,1885	0,1215	0,1071	0,1307	0,1341	0,1378	0,1451	0,1446	0,1420	0,1472	0,1328	0,1293	0,1481
POL	1,0287	1,0493	1,0877	1,1167	1,1167	1,0437	1,0065	INF	0,8197	0,7979	0,7997	0,7547	0,7548	0,7766	0,7257	0,7142	0,9062
PRT	0,0688	0,0680	0,0721	0,0846	0,0996	0,0936	0,1269	INF	0,1053	INF	0,1077	0,1260	0,1451	0,1100	0,1422	0,1380	0,1063
ESP	0,6067	0,5805	0,5263	0,4937	0,5142	0,5141	0,5675	0,6452	0,6551	0,6344	0,6037	0,6656	0,7146	0,6698	0,7012	0,6916	0,6115
SWE	0,1773	0,1692	0,1661	0,1729	0,1803	0,1659	0,1670	0,1641	0,1624	0,1482	0,1302	0,1519	0,1531	0,1535	0,1459	0,1388	0,1592
CHE	0,1130	0,1113	0,1106	0,1139	0,1087	0,1058	0,1024	0,1080	0,1043	0,1048	0,0976	0,0937	0,0901	0,0907	0,0855	0,0834	0,1015
TUR	0,2909	0,2893	0,3077	0,3410	0,3622	0,3385	0,3672	0,4006	0,3941	0,3911	0,4335	0,4379	0,4817	0,5003	0,5352	0,5436	0,4009
GBR	1,5358	1,4770	1,5288	1,5590	1,5806	1,5607	1,5574	1,5786	1,5431	1,4768	1,4094	1,3801	1,3345	1,3088	1,2201	1,1628	1,4508
USA	13,0606	13,0096	12,4837	12,6733	12,7127	13,0154	12,8156	12,9788	12,8005	12,7759	13,0959	13,3890	13,4324	13,2952	13,4754	13,5379	13,0345
MEAN	1,0210	1,0193	0,9968	1,0073	1,0206	1,0195	1,0251	1,0548	0,9811	1,0223	0,9816	0,9966	1,0045	0,9962	0,9978	0,9940	1,0087

Table 4.4.3. Environmental Performance Index

Bads: NO_X and CO_2

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	MEAN
AUS	INF	INF	INF	INF	INF	INF	INF	INF	1,2950	INF	1,2201	1,4921	1,5960	1,4560	1,5350	1,4746	1,4384
AUT	0,6001	0,6326	0,6527	0,6410	0,6419	0,6031	0,5956	0,6042	0,6025	0,5901	0,5724	0,5738	0,5458	0,5368	0,5556	0,5449	0,5933
BEL	0,7863	0,7790	0,7921	0,7944	0,8025	0,7423	0,7702	0,7758	0,7900	0,8215	0,7905	0,8044	0,7952	0,8088	0,7911	0,7832	0,7892
CAN	1,3041	1,2788	1,2142	1,2022	1,2474	1,2847	1,2975	1,3181	1,2892	1,2748	1,3015	1,3294	1,3599	1,3469	1,3531	1,3513	1,2971
DNK	0,8977	0,9156	0,9871	0,9867	1,0138	0,9304	0,8455	0,9409	1,0875	0,9074	0,9539	0,9783	0,9213	1,0013	0,9272	0,5174	0,9258
FIN	0,8848	0,9175	0,9397	1,0722	1,0930	1,0051	1,0220	1,1086	1,1639	1,0226	1,1552	1,2644	1,1689	1,2286	1,1436	1,0931	1,0802
FRA	0,6139	0,6226	0,6265	0,6044	0,5985	0,5593	0,5938	0,5784	0,5984	0,5749	0,5752	0,6000	0,6251	0,6364	0,6306	0,6241	0,6039
GER	0,8870	0,9135	0,9363	0,9512	0,9356	0,8816	0,8792	0,8317	0,8005	0,7812	0,7844	0,7071	0,6669	0,6796	0,6360	0,6325	0,8065
GRC	0,9146	0,9360	0,8890	0,8989	0,9920	1,0252	1,0579	1,1127	1,0458	1,0872	1,1386	1,2026	1,2306	1,2872	1,3001	1,3425	1,0913
HUN	1,0634	1,1081	1,1423	1,1492	1,1284	1,0798	1,0823	1,0795	1,1085	1,0661	1,0338	1,0116	1,0080	1,0745	1,0196	0,9580	1,0696
ISL	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	N/A
IRL	0,9030	0,9119	0,9964	1,1576	1,2257	1,2229	1,1700	1,0947	1,1525	1,1166	1,0890	1,0186	0,9654	0,9252	0,8801	0,8053	1,0397
ITA	0,5958	0,6119	0,6126	0,6093	0,6489	0,6583	0,6760	0,7094	0,7080	0,7072	0,7169	0,6957	0,7131	0,7214	0,7478	0,7545	0,6804
JPN	0,3173	0,3435	0,3276	0,3355	0,3641	0,3781	0,4060	INF	INF	INF	INF	INF	INF	INF	INF	INF	0,3532
KOR	1,0454	1,0300	1,0172	0,9727	0,9500	1,0108	1,0491	0,9508	0,8762	1,0089	1,0539	1,0177	0,9707	1,0141	1,0516	1,2507	1,0169
LUX	0,5473	0,5951	0,5752	0,5989	0,6304	0,6024	0,6386	0,8087	0,8262	0,8371	0,8014	0,7779	0,6648	0,6768	0,6682	0,6177	0,6792
MEX	0,9077	0,8719	0,7965	0,8259	0,8901	0,8699	0,8933	0,9313	0,9028	0,8974	0,8968	0,9158	1,0219	1,0369	1,0269	1,0040	0,9181
NLD	0,7824	0,8205	0,8350	0,8034	0,8404	0,8308	0,8545	0,8609	0,8343	0,8240	0,8081	0,7671	0,7487	0,7827	0,7292	0,7058	0,8017
NZL	0,5861	0,6378	0,6594	0,7666	0,8208	0,8376	0,8861	0,9287	0,9560	0,9396	0,9104	0,9851	1,0979	1,0751	1,1352	1,1199	0,8964
NOR	1,1265	1,2335	1,2891	1,3243	1,3220	0,8889	0,8041	0,9859	0,9860	1,0019	1,0409	1,0100	0,9844	1,0030	0,9013	0,8886	1,0494
POL	2,6417	2,6971	2,7334	2,7614	2,8054	2,6464	2,6485	INF	2,4465	2,3795	2,2934	2,1312	2,0445	2,0170	1,8086	1,7262	2,3854
PRT	0,4011	0,4276	0,4570	0,5255	0,5995	0,5431	0,7292	INF	0,5742	INF	0,5937	0,7004	0,8095	0,6160	0,7940	0,7654	0,6097
ESP	0,7852	0,7817	0,7203	0,6708	0,6803	0,6720	0,7281	0,8160	0,8151	0,8001	0,7870	0,8760	0,8992	0,8515	0,8883	0,8618	0,7896
SWE	0,6398	0,6139	0,6135	0,6441	0,6747	0,6349	0,6480	0,6438	0,6508	0,6160	0,5578	0,6479	0,6148	0,6301	0,6026	0,5659	0,6249
CHE	0,4029	0,4027	0,3975	0,4193	0,4128	0,4060	0,3891	0,4058	0,4001	0,4076	0,3858	0,3832	0,3923	0,3933	0,4373	0,3854	0,4013
TUR	0,6494	0,6398	0,6752	0,7080	0,7290	0,7088	0,7944	0,7946	0,7815	0,7528	0,7673	0,8756	0,9167	0,9180	0,9413	0,9652	0,7886
GBR	0,9658	0,9506	0,9836	0,9894	0,9904	0,9714	0,9828	1,0185	1,0250	1,0075	0,9550	0,9259	0,8803	0,8702	0,8098	0,7720	0,9436
USA	1,3616	1,3183	1,2624	1,2781	1,2829	1,3173	1,3002	1,3290	1,3292	1,3087	1,3246	1,3393	1,3474	1,3272	1,3287	1,3069	1,3164
MEAN	0,8697	0,8843	0,8897	0,9112	0,9354	0,8966	0,9132	0,8969	0,9633	0,9471	0,9426	0,9627	0,9611	0,9583	0,9478	0,9160	0,9247

Table 4.4.4. Environmental Quantity Index

Bads: NO_X and Organic Water Pollutant

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	MEAN
AUS	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	0,3829	0,3903	INF	INF	0,3866
AUT	0,1818	0,1854	0,1890	0,1870	0,1816	0,1795	0,1817	0,1724	0,1746	0,1760	0,1720	0,1692	0,1618	0,1601	0,1732	0,1720	0,1761
BEL	0,2709	0,2660	0,2596	0,2535	0,2573	0,2614	0,2690	0,2571	0,2594	0,2687	0,2730	0,2689	0,2643	0,2656	0,2717	0,2760	0,2652
CAN	1,0409	0,9861	1,0207	1,0210	1,0420	1,0718	1,0643	1,0693	1,0283	0,9855	0,9810	0,9526	0,9390	0,9434	0,9585	0,9314	1,0022
DNK	0,1696	0,1762	0,1916	0,1998	0,1947	0,1857	0,1779	0,2063	0,2214	0,2079	0,2131	0,2140	0,2056	0,2236	0,2189	INF	0,2004
FIN	0,1907	0,1925	0,2023	0,2033	0,2038	0,2035	0,2049	0,2014	0,1937	0,1874	0,1838	0,1828	0,1779	0,1814	0,1794	0,1711	0,1912
FRA	1,3231	1,3468	1,3430	1,3435	1,3270	1,3304	1,4120	1,2948	1,3300	1,3630	1,3586	1,3710	1,3588	1,3661	1,4057	1,4394	1,3571
GER	2,1466	2,1826	2,2038	2,2375	2,1557	2,1156	2,0591	1,9384	1,8811	1,9205	1,9150	1,7636	1,7540	1,7661	1,8136	1,8259	1,9799
GRC	0,1866	0,1863	0,1880	0,1872	0,1896	0,1880	0,1923	0,2020	0,2026	0,1986	0,1965	0,1943	0,1943	0,1910	0,1906	0,1879	0,1922
HUN	0,2686	0,2758	0,2837	0,2946	0,2961	0,3021	0,3079	INF	INF	INF	INF	INF	INF	INF	INF	0,2056	0,2793
ISL	0,0158	0,0165	0,0166	0,0168	0,0169	0,0163	0,0158	0,0151	0,0151	0,0150	0,0162	0,0163	0,0165	0,0156	0,0153	0,0151	0,0159
IRL	0,0703	0,0707	0,0736	0,0774	0,0826	0,0854	0,0868	0,0813	0,0843	0,0882	0,0886	0,0860	0,0849	0,0883	0,0909	0,0910	0,0831
ITA	1,0594	1,0694	1,0531	1,0724	1,1152	1,0728	1,0920	1,1404	1,1559	1,1851	1,1505	1,0978	1,0839	1,0775	1,0602	1,0429	1,0955
JPN	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	N/A
KOR	0,5797	0,6148	0,6113	0,6699	0,7116	0,7961	0,8511	0,7436	0,7194	0,8114	0,8820	0,8799	0,8689	0,8999	0,9615	0,9952	0,7873
LUX	0,0112	0,0113	0,0115	0,0120	0,0118	0,0121	0,0125	0,0133	0,0137	0,0141	0,0144	0,0140	0,0137	0,0138	0,0142	0,0144	0,0130
MEX	INF	0,5815	0,5871	0,5681	0,5159	0,4854	0,4978	0,5172	0,5207	0,5266	0,4686	0,4326	0,3968	0,4282	0,4112	0,4068	0,4896
NLD	0,3652	0,3714	0,3831	0,3850	0,3892	0,3731	0,3689	0,3726	0,3704	0,3689	0,3588	0,3475	0,3432	0,3468	0,3397	0,3386	0,3639
NZL	0,1141	0,1172	0,1165	0,1166	0,1114	0,1100	0,1114	0,1054	0,1047	0,1140	0,1167	0,1122	0,1127	0,1139	0,1140	0,1135	0,1128
NOR	0,1345	0,1421	0,1484	0,1570	0,1556	0,1501	0,1460	0,1436	0,1391	0,1359	0,1377	0,1397	0,1404	0,1439	0,1390	0,1374	0,1432
POL	1,1297	1,1539	1,1168	1,1330	1,1200	1,1216	1,0784	INF	0,9006	0,8621	0,8532	0,8590	0,8743	0,9099	0,9409	0,8713	0,9950
PRT	INF	INF	INF	0,1541	0,1763	0,1991	0,2194	0,2886	0,3057	0,3209	0,3276	0,3235	0,3215	0,3289	0,3384	0,3840	0,2837
ESP	0,7187	0,7133	0,6575	0,6618	0,6741	0,6870	0,7351	0,7985	0,8205	0,8313	0,8944	0,8805	0,8759	0,8812	0,9153	0,9410	0,7929
SWE	0,2780	0,2847	0,2935	0,2986	0,2976	0,2942	0,2861	0,2467	0,2529	0,2478	0,2387	0,2407	0,2274	0,2290	0,2289	0,2239	0,2605
CHE	0,1855	0,1920	0,1991	0,2047	0,2053	0,2171	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	0,2006
TUR	0,3394	0,3537	0,3606	0,3901	0,4096	0,4202	0,4436	0,4529	0,4436	0,4665	0,4935	0,4797	0,5047	0,5281	0,5576	0,5665	0,4506
GBR	1,7180	1,7351	1,7744	1,8216	1,8409	1,8608	1,8746	1,8309	1,7635	1,7457	1,6676	1,6336	1,5911	1,5842	1,5657	1,5334	1,7213
USA	8,6842	8,3339	8,1356	7,7779	8,0630	7,7823	7,6574	7,9016	7,7621	8,1253	8,2770	8,1792	7,8295	7,9387	8,1043	8,1944	8,0467
MEAN	0,8826	0,8624	0,8568	0,8248	0,8363	0,8278	0,8538	0,8693	0,8610	0,8819	0,8866	0,8683	0,8290	0,8406	0,8754	0,8783	0,8584

Table 4.4.5. Environmental Performance Index

Bads: NO_X and Organic Water Pollutant

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	MEAN
AUS	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	0,7093	0,7240	INF	INF	0,7167
AUT	0,7695	0,8203	0,8465	0,8429	0,8338	0,8343	0,8394	0,7802	0,7699	0,7830	0,7719	0,7664	0,7330	0,7353	0,8130	0,8008	0,7963
BEL	0,8558	0,8579	0,8602	0,8525	0,8730	0,8805	0,9037	0,8573	0,8599	0,8967	0,9384	0,9300	0,9177	0,9462	0,9670	0,9785	0,8985
CAN	1,1623	1,0860	1,0998	1,1025	1,1128	1,1366	1,1380	1,1792	1,1723	1,1395	1,1192	1,0727	1,0541	1,0746	1,0750	1,0376	1,1101
DNK	0,9477	0,9858	1,0636	1,1049	1,1083	1,0869	1,0738	1,2556	1,3357	1,2675	1,3078	1,2840	1,2462	1,3625	1,3365	INF	1,1845
FIN	1,2615	1,2977	1,3759	1,3983	1,4002	1,3936	1,3734	1,3904	1,4675	1,5013	1,4958	1,4597	1,3615	1,3851	1,3212	1,2226	1,3816
FRA	0,7563	0,7984	0,8088	0,8116	0,8108	0,8106	0,8523	0,7808	0,8030	0,8329	0,8565	0,8657	0,8578	0,8806	0,9183	0,9307	0,8359
GER	0,8644	0,8968	0,9168	0,9326	0,9134	0,9025	0,8817	0,8335	0,8115	0,8303	0,8504	0,7862	0,7782	0,8037	0,8388	0,8464	0,8555
GRC	0,9398	0,9634	0,9718	0,9828	1,0308	1,0232	1,0406	1,1127	1,0903	1,0888	1,1086	1,1112	1,1090	1,0998	1,0968	1,0683	1,0524
HUN	1,4908	1,5742	1,6739	1,7553	1,7606	1,8874	1,9816	INF	INF	INF	INF	INF	INF	INF	INF	1,6258	1,7187
ISL	1,9500	2,0437	2,0726	2,0343	1,9832	1,9871	1,9752	1,9037	1,9201	2,0143	2,1547	2,1602	2,2345	2,0830	2,0137	1,9773	2,0317
IRL	1,0681	1,0851	1,1411	1,2455	1,3201	1,3562	1,3474	1,1837	1,2102	1,2444	1,2262	1,1377	1,0284	1,0288	0,9819	0,9228	1,1580
ITA	0,6328	0,6535	0,6482	0,6613	0,6906	0,6680	0,6843	0,7166	0,7244	0,7550	0,7530	0,7253	0,7093	0,7234	0,7246	0,7193	0,6994
JPN	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	N/A
KOR	1,3515	1,3791	1,3361	1,3597	1,3395	1,4030	1,4402	1,1663	1,0347	1,1388	1,1945	1,1309	1,0576	1,0587	1,1354	1,3370	1,2414
LUX	0,8463	0,8382	0,8463	0,8452	0,8468	0,8106	0,7907	0,8471	0,8275	0,8261	0,7856	0,7523	0,7261	0,7372	0,7250	0,7121	0,7977
MEX	INF	0,5810	0,5889	0,6118	0,5671	0,5460	0,5545	0,5589	0,5412	0,5356	0,4755	0,4331	0,4420	0,4788	0,4519	0,4351	0,5201
NLD	0,8364	0,8634	0,8940	0,9008	0,9304	0,9074	0,8871	0,8819	0,8639	0,8620	0,8431	0,8163	0,7944	0,8047	0,7853	0,7739	0,8528
NZL	1,1924	1,2215	1,2490	1,2640	1,2452	1,2905	1,3326	1,3058	1,3315	1,4603	1,4236	1,3360	1,4298	1,4580	1,4806	1,4863	1,3442
NOR	0,9616	1,0012	1,0344	1,0903	1,0918	1,0982	1,0955	1,0833	1,0235	0,9877	0,9873	0,9759	0,9735	0,9800	0,9435	0,9440	1,0170
POL	2,9010	2,9660	2,8065	2,8015	2,8137	2,8437	2,8377	INF	2,6878	2,5710	2,4468	2,4260	2,3683	2,3633	2,3447	2,1061	2,6189
PRT	INF	INF	INF	0,9578	1,0610	1,1555	1,2604	1,6181	1,6663	1,7326	1,8068	1,7982	1,7934	1,8426	1,8896	2,1296	1,5932
ESP	0,9301	0,9606	0,9000	0,8993	0,8918	0,8980	0,9433	1,0100	1,0207	1,0484	1,1660	1,1587	1,1022	1,1203	1,1594	1,1725	1,0238
SWE	1,0030	1,0326	1,0841	1,1127	1,1139	1,1265	1,1102	0,9677	1,0138	1,0299	1,0230	1,0266	0,9132	0,9399	0,9450	0,9131	1,0222
CHE	0,6612	0,6946	0,7156	0,7535	0,7796	0,8327	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	0,7395
TUR	0,7576	0,7823	0,7913	0,8099	0,8245	0,8799	0,9597	0,8981	0,8797	0,8979	0,8735	0,9592	0,9604	0,9691	0,9807	1,0059	0,8894
GBR	1,0804	1,1167	1,1416	1,1561	1,1535	1,1581	1,1829	1,1812	1,1715	1,1910	1,1300	1,0960	1,0495	1,0533	1,0392	1,0180	1,1199
USA	0,9053	0,8445	0,8227	0,7844	0,8136	0,7877	0,7769	0,8096	0,8060	0,8323	0,8372	0,8181	0,7854	0,7925	0,7991	0,7910	0,8129
MEAN	1,0886	1,0938	1,1076	1,1181	1,1273	1,1425	1,1705	1,0575	1,1264	1,1445	1,1490	1,1261	1,0854	1,0978	1,1153	1,1231	1,1171

Table 4.4.6. Environmental Quantity Index

Bads: CO_2 and Organic Water Pollutant

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	MEAN
AUS	0,5794	0,5633	0,5922	0,5735	0,5706	0,5911	0,5909	0,5552	0,5476	0,5211	0,5166	0,4983	0,4671	0,4450	0,4812	0,4898	0,5364
AUT	0,1816	0,1890	0,1811	0,1758	0,1781	0,1673	0,1674	0,1800	0,1725	0,1566	0,1615	0,1644	0,1722	0,1637	0,1693	0,1735	0,1721
BEL	0,2972	0,3008	0,2935	0,2846	0,2804	0,2640	0,2640	0,2750	0,2790	0,2704	0,2584	0,2734	0,2779	0,2738	0,2700	0,2741	0,2773
CAN	1,0078	0,9429	0,9900	0,9783	0,9871	1,0242	1,0326	0,9835	0,9315	0,9047	0,8923	0,8828	0,8869	0,8857	0,9142	0,9068	0,9470
DNK	0,1583	0,1602	0,1797	0,1773	0,1744	0,1587	0,1391	0,1653	0,1808	0,1506	0,1650	0,1792	0,1749	0,1663	0,1786	0,1947	0,1689
FIN	0,1503	0,1519	0,1588	0,1720	0,1715	0,1594	0,1588	0,1571	0,1463	0,1276	0,1356	0,1477	0,1463	0,1552	0,1503	0,1490	0,1524
FRA	1,3551	1,3321	1,2537	1,1906	1,1717	1,0630	1,1264	1,1608	1,1351	1,0045	0,9866	0,9599	1,1083	1,0664	1,0896	1,1343	1,1336
GER	2,4489	2,4139	2,4076	2,4440	2,3812	2,3520	2,3234	2,3242	2,3072	2,2479	2,2146	2,1154	2,1758	2,1758	2,1347	2,1410	2,2880
GRC	0,1653	0,1668	0,1705	0,1663	0,1721	0,1762	0,1857	0,1845	0,1721	0,1821	0,1831	0,1801	0,1809	0,1774	0,1809	0,1829	0,1767
HUN	0,3095	0,3220	0,2924	0,2738	0,2823	0,2396	0,2059	INF	0,1896	INF	INF	0,1273	0,1870	0,1422	INF	INF	0,2338
ISL	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	N/A
IRL	0,0811	0,0816	0,0786	0,0843	0,0859	0,0856	0,0801	0,0830	0,0883	0,0821	0,0843	0,0869	0,0955	0,0887	0,0914	0,0932	0,0857
ITA	1,0398	1,0479	1,0185	0,9906	1,0162	0,9922	1,0103	1,0251	1,0328	1,0482	1,0030	0,9939	1,0132	0,9902	0,9965	0,9954	1,0134
JPN	2,9176	3,1037	2,9335	2,9222	2,9252	3,0931	3,0413	3,2144	3,1382	3,0224	3,0792	3,1895	3,2752	3,1860	3,3293	3,4790	3,1156
KOR	0,5065	0,5518	0,5692	0,5792	0,6186	0,6764	0,6912	0,7376	0,7436	0,7725	0,8449	0,9033	0,9653	0,9961	0,9857	1,0186	0,7600
LUX	0,0235	0,0240	0,0239	0,0236	0,0225	0,0222	0,0231	0,0221	0,0220	0,0214	0,0207	0,0205	0,0196	0,0192	0,0189	0,0188	0,0216
MEX	INF	0,5533	0,5700	0,5477	0,5176	0,5018	0,5157	0,4972	0,4872	INF	INF	INF	INF	INF	INF	INF	0,5238
NLD	0,3401	0,3538	0,3660	0,3514	0,3549	0,3354	0,3614	0,3667	0,3673	0,3606	0,3565	0,3485	0,3480	0,3745	0,3616	0,3637	0,3569
NZL	0,0763	0,0777	0,0779	0,0833	0,0840	0,0814	0,0841	0,0804	0,0770	0,0731	0,0699	0,0798	0,0840	0,0832	0,0845	0,0867	0,0802
NOR	0,2039	0,1880	0,1926	0,1876	0,1854	0,1293	0,1098	0,1324	0,1409	0,1420	0,1477	0,1511	0,1510	0,1502	0,1202	0,1158	0,1530
POL	1,2894	1,3186	1,2701	1,2826	1,2889	1,2263	1,1454	0,9870	0,9355	0,8908	0,9070	0,8946	0,9146	0,9241	0,8791	0,8252	1,0612
PRT	0,1244	0,1054	0,0995	INF	0,1104	0,0879	0,1388	INF	INF	INF	INF	INF	0,1482	INF	INF	INF	0,1164
ESP	0,6550	0,6250	0,6068	0,5646	0,5841	0,5863	0,6308	0,6447	0,6270	0,6119	0,5972	0,6471	0,7017	0,6606	0,7075	0,7477	0,6374
SWE	0,2027	0,2032	0,2051	0,1995	0,1966	0,1890	0,1817	0,1719	0,1616	0,1479	0,1244	0,1444	0,1644	0,1614	0,1613	0,1684	0,1740
CHE	0,1670	0,1375	INF	INF	0,1327	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	0,1457
TUR	0,3197	0,3339	0,3498	0,3830	0,4003	0,3728	0,3901	0,4082	0,3885	0,3890	0,4227	0,4225	0,4493	0,4530	0,4620	0,4730	0,4011
GBR	1,7314	1,6972	1,6825	1,6902	1,7005	1,6927	1,6498	1,6324	1,5845	1,4956	1,4647	1,4777	1,4982	1,4824	1,5049	1,5112	1,5935
USA	8,4059	7,0011	7,0661	6,9268	6,9958	6,7983	6,8493	6,5815	6,3824	7,4488	7,5272	7,5730	7,2718	7,2693	7,5914	7,8860	7,2234
MEAN	0,9515	0,8869	0,9088	0,9301	0,8737	0,8872	0,8884	0,9404	0,8895	0,9596	0,9636	0,9359	0,9151	0,9371	0,9940	1,0186	0,9300

Table 4.4.7. Environmental Performance Index

Bads: CO_2 and Organic Water Pollutant

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	MEAN
AUS	1,1445	1,1140	1,1626	1,1387	1,1180	1,1555	1,1607	1,1344	1,1260	1,0576	1,0131	0,9593	0,8652	0,8256	0,9052	0,9209	1,0501
AUT	0,7684	0,8362	0,8111	0,7925	0,8176	0,7777	0,7734	0,8143	0,7604	0,6968	0,7251	0,7447	0,7799	0,7521	0,7948	0,8077	0,7783
BEL	0,9389	0,9702	0,9725	0,9571	0,9515	0,8891	0,8867	0,9172	0,9248	0,9024	0,8883	0,9454	0,9649	0,9757	0,9609	0,9718	0,9386
CAN	1,1253	1,0384	1,0666	1,0565	1,0542	1,0862	1,1041	1,0846	1,0620	1,0461	1,0181	0,9941	0,9955	1,0088	1,0253	1,0101	1,0485
DNK	0,8841	0,8962	0,9976	0,9806	0,9927	0,9290	0,8396	1,0061	1,0908	0,9178	1,0127	1,0752	1,0604	1,0138	1,0905	1,2594	1,0029
FIN	0,9940	1,0239	1,0803	1,1828	1,1785	1,0916	1,0646	1,0846	1,1083	1,0227	1,1031	1,1797	1,1200	1,1852	1,1067	1,0648	1,0994
FRA	0,7746	0,7897	0,7551	0,7193	0,7159	0,6477	0,6799	0,7000	0,6853	0,6138	0,6220	0,6061	0,6996	0,6875	0,7118	0,7334	0,6964
GER	0,9862	0,9918	1,0017	1,0187	1,0090	1,0033	0,9948	0,9993	0,9953	0,9718	0,9834	0,9431	0,9654	0,9902	0,9873	0,9925	0,9896
GRC	0,8326	0,8625	0,8813	0,8732	0,9356	0,9591	1,0051	1,0165	0,9264	0,9984	1,0329	1,0297	1,0327	1,0217	1,0411	1,0401	0,9681
HUN	1,7178	1,8381	1,7258	1,6315	1,6787	1,4966	1,3255	INF	1,4549	INF	INF	1,0235	1,4864	1,1662	INF	INF	1,5041
ISL	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	N/A
IRL	1,2322	1,2513	1,2175	1,3554	1,3721	1,3590	1,2422	1,2088	1,2688	1,1589	1,1663	1,1495	1,1565	1,0340	0,9876	0,9446	1,1940
ITA	0,6211	0,6404	0,6269	0,6109	0,6293	0,6178	0,6331	0,6442	0,6472	0,6678	0,6565	0,6566	0,6630	0,6648	0,6811	0,6866	0,6467
JPN	0,7866	0,8437	0,7889	0,7884	0,7850	0,8166	0,7938	0,8176	0,7736	0,7538	0,7766	0,8266	0,8660	0,8269	0,8825	0,9741	0,8188
KOR	1,1808	1,2378	1,2440	1,1755	1,1645	1,1919	1,1695	1,1568	1,0695	1,0843	1,1443	1,1610	1,1749	1,1719	1,1640	1,3685	1,1787
LUX	1,7768	1,7725	1,7633	1,6633	1,6137	1,4906	1,4586	1,4052	1,3336	1,2499	1,1323	1,1011	1,0359	1,0246	0,9651	0,9319	1,3574
MEX	INF	0,5528	0,5717	0,5899	0,5690	0,5644	0,5745	0,5373	0,5064	INF	INF	INF	INF	INF	INF	INF	0,5583
NLD	0,7790	0,8223	0,8541	0,8221	0,8484	0,8159	0,8690	0,8678	0,8568	0,8424	0,8377	0,8188	0,8057	0,8688	0,8360	0,8313	0,8360
NZL	0,7976	0,8102	0,8357	0,9033	0,9389	0,9554	1,0056	0,9964	0,9800	0,9370	0,8524	0,9501	1,0661	1,0647	1,0973	1,1348	0,9578
NOR	1,4574	1,3245	1,3425	1,3030	1,3003	0,9462	0,8238	0,9984	1,0365	1,0324	1,0590	1,0557	1,0471	1,0235	0,8162	0,7955	1,0851
POL	3,3110	3,3893	3,1918	3,1714	3,2380	3,1092	3,0140	2,8704	2,7920	2,6567	2,6012	2,5264	2,4773	2,4003	2,1908	1,9946	2,8084
PRT	0,7252	0,6629	0,6306	INF	0,6647	0,5102	0,7973	INF	INF	INF	INF	INF	0,8266	INF	INF	INF	0,6882
ESP	0,8477	0,8416	0,8306	0,7672	0,7728	0,7664	0,8094	0,8154	0,7800	0,7717	0,7784	0,8516	0,8830	0,8398	0,8962	0,9316	0,8240
SWE	0,7316	0,7371	0,7578	0,7432	0,7358	0,7236	0,7049	0,6744	0,6476	0,6149	0,5331	0,6160	0,6600	0,6623	0,6660	0,6866	0,6809
CHE	0,5954	0,4975	INF	INF	0,5039	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	0,5323
TUR	0,7137	0,7386	0,7677	0,7953	0,8057	0,7806	0,8441	0,8096	0,7704	0,7488	0,7483	0,8448	0,8549	0,8313	0,8124	0,8399	0,7941
GBR	1,0888	1,0923	1,0825	1,0727	1,0655	1,0536	1,0411	1,0532	1,0525	1,0203	0,9925	0,9914	0,9882	0,9856	0,9988	1,0033	1,0364
USA	0,8763	0,7094	0,7145	0,6986	0,7059	0,6881	0,6949	0,6744	0,6627	0,7630	0,7614	0,7575	0,7294	0,7257	0,7485	0,7613	0,7295
MEAN	1,0649	1,0476	1,0644	1,0724	1,0432	1,0164	1,0119	1,0120	1,0125	0,9795	0,9756	0,9920	1,0082	0,9896	0,9724	0,9863	1,0156