A2003:012

Swedish Growth and Welfare in Perspective

Hans-Olof Hagén
Michael Olsson
Anders Wiberg
Kurt Lundgren

INSTITUTET FÖR TILLVÄXTPOLITISKA STUDIER

Swedish Growth and Welfare in Perspective

Hans-Olof Hagén
Michael Olsson
Anders Wiberg
Kurt Lundgren

INSTITUTET FÖR
TILLVÄXTPOLITISKA
STUDIER

ITPS, Institutet för tillväxtpolitiska studier
Studentplan 3, 831 40 Östersund
Telefon 063 16 66 00
Telefax 063 16 66 01
E-post info@itps.se
www.itps.se
ISSN 1652-0483
Elanders Gotab, Stockholm 2003

För ytterligare information kontakta Hans-Olof Hagén
Telefon 08 456 67 36
E-post hans-olof.hagen@itps.se

Förord

Economic growth, its causes and consequences is discussed every day in the political debate. Sweden is compared with other countries with more or less plausible explanations on why earlier growth was slow, present income are relatively low and present growth is relatively high.

This report analyse measures on production inputs with economic growth and welfare results. Responsible for the text are Hans-Olof Hagén (project leader), Kurt Lundgren, Michael Olsson (secretary) and Anders Wiberg.

Stockholm in September

Sture Öberg,
Director-General

Innehåll

1 Introduction

It is evident that Sweden has had a problem with economic growth. Moreover, to some degree most political parties identify economic growth as an important (intermediate) policy target. A good example is the governments policy declaration at the opening of the parliament this autumn. In addition to the observation that economic growth has been relatively slow in Sweden, two other observations can be made. First, the level of welfare in Sweden is still perceived as relatively high (UNDP, 2002; Berger-Schmitt, 2002). This is probably the main reason why the general public in Sweden has accepted the deterioration of its relative economic standard. Second, indicators of social capabilities assumed to influence economic performance, i.e. ICT availability and R&D expenditure, are also perceived relatively favourable in Sweden.

Given these three observations, the real question is to what extent this situation can be explained and understood. A fundamental part of this project is to form a database with variables of economic indicators, ICT indicators, research expenditure, education variables etc for the OECD countries over time. In this paper, (some of) the data is used to analyze Swedish welfare in relation to economic activity, to the available inputs, and to the situation in other countries. The political controversy over the fact that Sweden is ranked 2nd (UNDP, 2002) in welfare and 17th (OECD, 2002a) in economic activity is studied. The aim of this study is to contribute to the debate, since it seems that, in the political arena, it is sometimes unclear what is actually being discussed. For example, it transpires that, with certain variable transformations, the ranking can be affected considerably. It is shown that economic production in Sweden is inefficient. Given the available input, Swedish production can be increased substantially. Still, the production of welfare is found to be (almost) efficient. A relatively large share of Swedish welfare stems from expected length of life, literacy, educational attainment, and the environment. Moreover, a relatively low share of welfare stems from income. Overall there is a strong correlation between production (GDP per capita) and other welfare components (UNDP, 2002; Maddison, 2001). The bottom line is that the sustainability of the Swedish welfare level is questioned, since the economic resources are relatively limited. It suffices to say that a long period of limited economic resources may eventually have effects on the potential level of welfare. In other words, the current welfare ranking may be based on the relative economic abundance of the 1950s and 1960s.

In the debate it is often heard that Sweden should strive towards achieving the top position in the economic rating of countries. Moreover, policy targets may be economic activity and welfare, which are related to the demographic situation.

The remainder of the paper is divided into the following chapters. In Chapter 2 the data material is presented. The empirical results are presented in Chapter 3. Finally, Chapter 4 contains policy conclusions and suggestions for future research. Appendix 1 contains a description of the methods used in the analysis. In Appendix 2 the welfare and input data and indices are presented, and the calculation of the indices is described. In addition, the procedure is exemplified with the aid of Sweden. The transformation procedure of the estimated efficiency parameters is presented in Appendix 3. Appendix 4 presents the results of using weighted averages, with weights estimated by factor analysis. In Appendix 5, the results based on entropy-like weighted averages are presented.

2 Description of data

The following description of data is divided into four parts. The variables used are presented in Section 2.1. Data concerning economic activity, welfare, and inputs are discussed in more detail, in Sections 2.2-2.4, respectively.

2.1 Variables and transformation of variables

OECD is our most important source of information. Table 2.1 contains a list of the variables used in the empirical part of the report. The list is divided into positive and negative welfare components, as well as inputs to production of these welfare components.

The data are transformed into indices, ranging from zero to one (UNDP, 2002). The principle is described in Appendix 2. The better the situation, the closer the index value is to one. Moreover, the complete data set and the resulting indices for all countries are presented in Appendix 2 (A2.1-A2.4). It may be discussed whether GDP is the most appropriate income measure. Lindbeck (2000) and Ministry of Finance (2000) describe the pros and cons of the GDP measure. The GDP measure has to be made comparable between countries. In other words, the GDP measure is adjusted for price level differences, and different sizes of population. Moreover, a common currency has to be used. Black market activities, as well as production at home, are not incorporated into the GDP measure. In addition, the treatment of the public sector is problematic. Moreover, the environment and the issue of distribution are ignored by the GDP measure. Nevertheless, GDP per capita, Y, is the selected indicator for economic activity. In addition, a logged income measure is formed. Measures of welfare are discussed in Berger-Schmitt and Jankowitsch (1999), Berger-Schmitt and Noll (2000), Berger-Schmitt (2001), Berger-Schmitt (2002), and UNDP (2002). Length of life is selected as the general indicator of physical well-being among the male and female population, M and F, respectively. Note that pollution (measured as CO_2 emissions per capita), Z, is a negative welfare component.

TABLE 2.1

A list of welfare components and inputs to production of welfare

Welfare components	$\mathbf{W}$	**Inputs**	$\mathbf{X}$
Positive		Potential labor force	L
GDP per head	Y	Human capital	H
Expected length of life for men	M	R&D expenditure per head	R
Expected length of life for women	F	ICT	I
Negative			
Pollution (CO_2, ton per head)	Z		

The share of the population of working age (16-64), L, is used as an indicator of the potential labor available. Moreover, the share with high education is the selected measure of human capital, H. R&D expenditure per person, R, is incorporated into the analyses. The number of Internet hosts per head, I, is used as a measure of the importance of the new economy. Physical capital is an important input for production, but not included in the analyses. Note that OECD will present official physical capital estimates in the beginning of 2003. OECD (1997) published an incomplete set of capital data, which also is considered inadequate due to age. Moreover, OECD has published two related studies concerning the measurement of capital and productivity (OECD, 2001f, 2001g). However, according to Ministry of Finance (2000, p. 29), the development of the capital-labor ratio has been relatively weak in Sweden, due to low investments. In particular, the low wages in the public sector have prevented this sector from undergoing much needed structural changes. The analyses in this paper can be repeated to incorporate more recent and additional data, as they become available. We realize that other data could have been used. For example, data on local environmental effects may be available.

Table 2.2 presents the Swedish index for each variable, the median index and the standard deviation of the index for the OECD countries. Sweden has the median income index, but high expected length of life indices and pollution indices, (i.e. relatively low emissions). All inputs in Sweden, except the share of population in the labor force, are above the median value. In other words, in relative terms Sweden lacks labor. In Sweden, the low share of the population of working age is countered (to some extent) by more education, higher R&D expenditure and so on. R&D expenditure is relatively stable over time, and for that reason R&D expenditure has not lagged.

TABLE 2.2

The Swedish position (2000). The index is defined in such a way that the maximum index value is 100 % (Appendix 2)

Variable		**†**	**Swedish index (%)**	**Median index (%)**	**Standard deviation (%)**
GDP per head	Y		61	61	24
	$\ln Y$		77	77	24
Expected male length of life	M	+	97	77	25
Expected female length of life	F	+	84	74	20
CO_2 emissions	Z	+	82	62	22
Share of population between 16-64 years	L	-	35	62	18
Share with high education	H	+	85	74	30
R&D expenditure	R	+	95	46	28
Internet	I	+	45	14	24

† A + (-) sign is given when the Swedish index is above (below) the median index.

2.2 Economic activity

Whether or not Sweden has a growth problem has been the subject of debate. This debate has been exemplified by Korpi (1991), the Economists' Expert Group of the Industrial Council for Social and Economic Studies (1991), Korpi (2000) and Henrekson (2001). A limited list of (other) Swedish publications related to this study is Henrekson (1992), Calmfors and Persson (1999), Lindbeck (2000), Ministry of Finance (2000), Andersson (2002), Ministry of Industry, Employment, and Communications (2002) and Wallen (2002). Landau, Taylor and Wright (1996) is an example of the international discussion of economic growth. Sweden's relative position in respect of GDP per capita has gradually declined, and over thirty years Sweden has moved down at least nine places in the ranking of countries (Table 2.3 and Figures 2.1-2.4). Moreover, growth in income is even smaller than growth in production, due to interest payments on the foreign debt (Ministry of Finance, 2000). The Swedish ranking in 2001 had deteriorated to 18th position but, in 2002, it had improved to 14th position (preliminary, OECD).

TABLE 2.3

The Swedish ranking in GDP per capita, various years

Year	**Rank**		
	OECD†	OECD‡	SE*
1970	7	5	4
1980	11	7	8
1990	13	6	-
2000	16	17	17

† GDP per capita at the price levels and PPPs of 1995 (US dollars). Source: OECD Statistics.

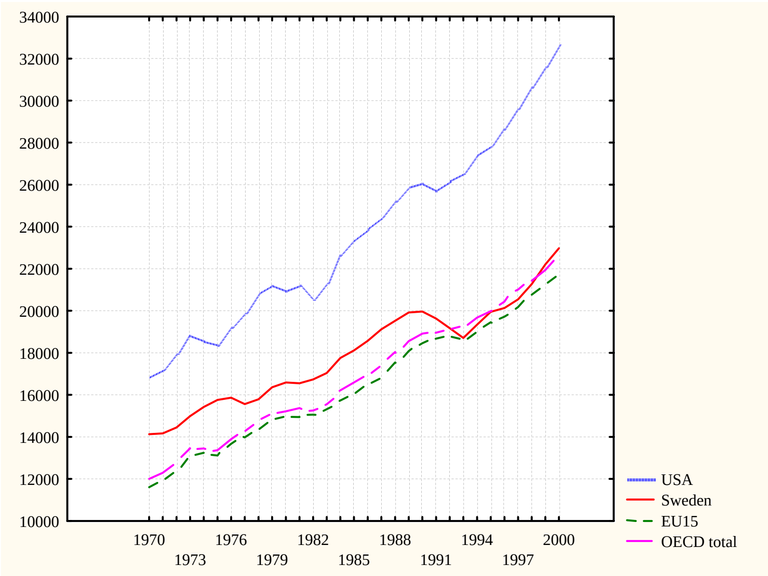
‡ GDP per capita at current prices and current PPPs (US dollars). Source: OECD Statistics.

Ranking according to The Confederation of Swedish Enterprise, (www.svensktnaringsliv.se).

GDP per capita in Sweden, EU, the OECD and the US are compared in Figures 2.1-2.4. The EU and OECD are made up, to a large extent, of the same countries. In Figure 2.1 we can see that Swedish GDP per capita is a great deal lower than that in the US. Moreover, it can be seen that Swedish GDP per capita has dropped from 84 per cent to 70 per cent of that in the US (Figure 2.2). In Figure 2.3, GDP per capita in 1970 is used as the base. GDP per capita in the US and Swedish has grown by 93 and 63 per cent, respectively. In Figure 2.4, the growth figures are related. It can be seen that GDP per capita in the US has grown by 19 per cent more than Swedish GDP per capita, $(1.93/1.63 \approx 1.19)$. It can be clearly seen that economic growth in Sweden has been smaller than growth in many other countries. In principle, the same picture would be obtained from using current prices and current PPPs. However, the Swedish relative decline would be greater (Table 2.3). In this respect, the integration of Europe may have significant positive effects in Sweden, via the degree of competition.

FIGURE 2.1

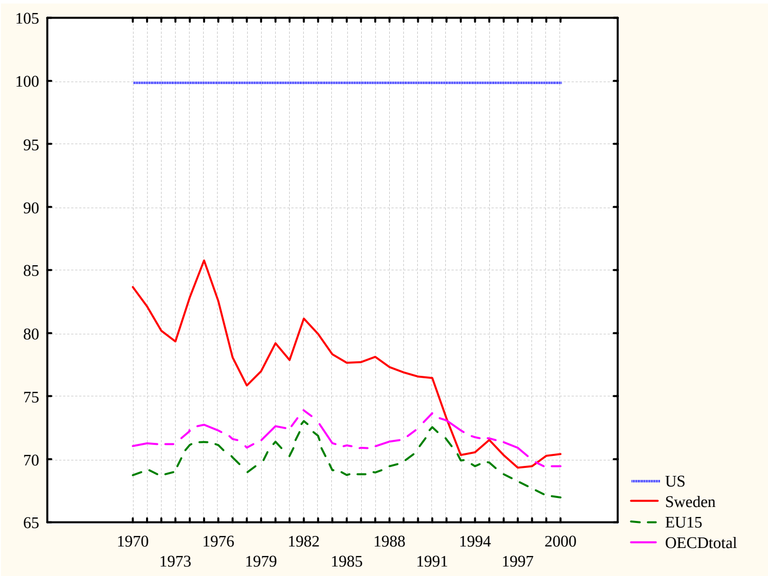
GDP per capita over time (1995 prices and PPPs)



Source: OECD Statistics

FIGURE 2.2

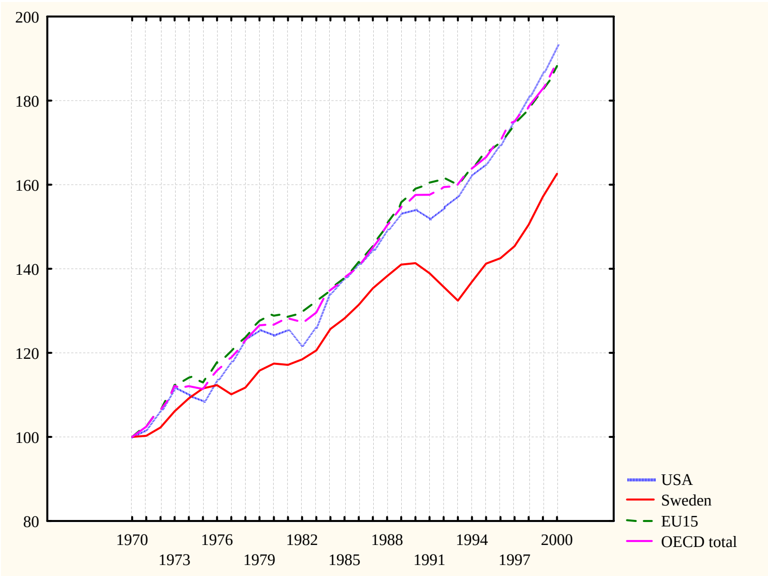
GDP per capita as a share of GDP per capita in the US (1995 prices and PPPs)



Source: OECD Statistics

FIGURE 2.3

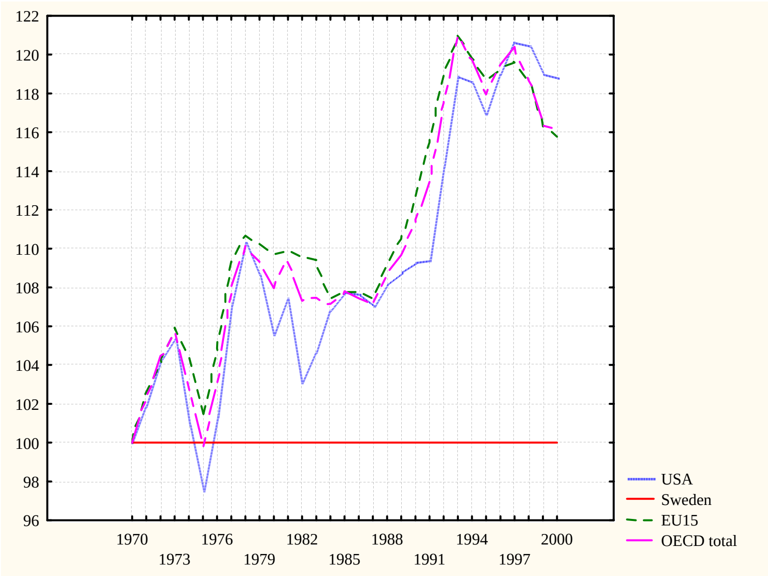
GDP per capita index (1995 prices and PPPs, base year 1970)



Source: OECD Statistics

FIGURE 2.4

The index quotas using the Swedish index as the base (1995 prices and PPPs)



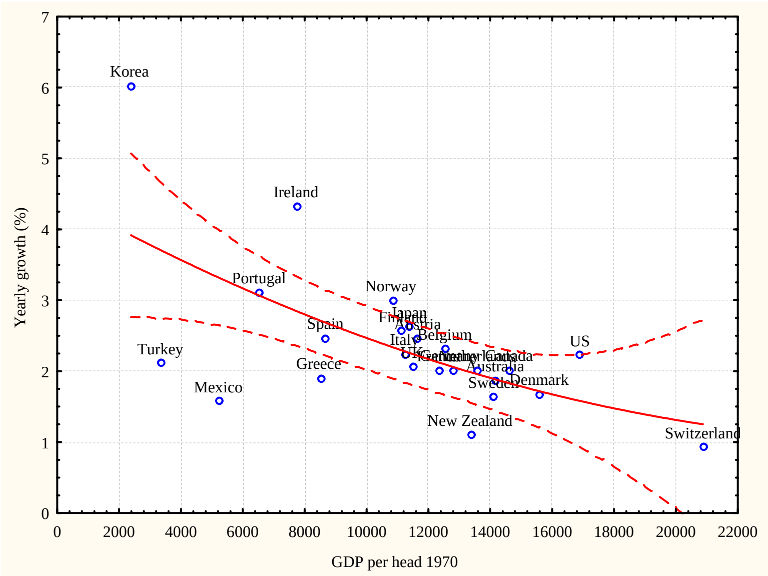
Source: OECD Statistics.

If Sweden manages to learn from and adopt experience gained in other regions and countries, the catch-up hypothesis may work in our favour in the years to come (Lindbeck, 2000). The catch-up hypothesis is visualised in Figures 2.5-2.6. However, it is not likely that we will recover economically in a short period of time. To catch up with (the PPP adjusted GDP per capita in) Denmark and the US, GDP per capita in Sweden needs to grow faster - how much faster depends on the time period in question.

Additional growth of the type that $(1+g_{Sweden})/(1+g_{other\ country})=1.01$, would have the effect that Sweden's GDP per capita would be equal to the level in Denmark and the US after 16 and 39 years respectively (Figure 2.7). This indicates that a serious attempt to catch up economically is very much a long-term goal. Other examples of exponential catching-up calculations are presented in Svedberg (1999). Moreover, exponential growth may also be questioned in itself. However, exponential growth is an approximation of logistic growth (Figure 2.8).

FIGURE 2.5

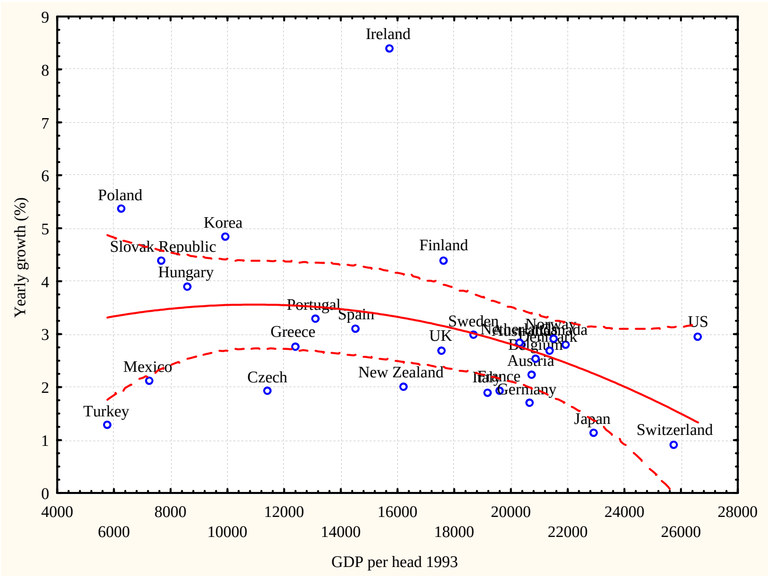
Yearly growth in GDP per capita during the period 1970 to 2000 related to GDP per capita in 1970



Source: OECD Statistics

FIGURE 2.6

Yearly growth in GDP per capita during the period 1993 to 2000 related to GDP per capita in 1993



Source: OECD Statistics

Also, by comparing Figures 2.5 and 2.6 it can be observed that the catch-up relationship is weaker over shorter periods of time. It should be noted that when production is too small, i.e. below potential, for some reason during a period of time, this loss in production will not be regained even if Sweden manages to catch up in the future. The different demographic situation of countries may accomplish a catch-up effect, since the share of the population in working age may converge. However, in relation to other countries, e.g. the US, the demographic situation will continue to work against Sweden, and Europe (The Economist, 2002). Jones (2002) argues that the growth in the US has exceeded the trend growth and will eventually be reduced.

FIGURE 2.7

How much faster must Swedish GDP per capita grow each year over a specific time period to be equal to GDP per capita in Denmark and the US?

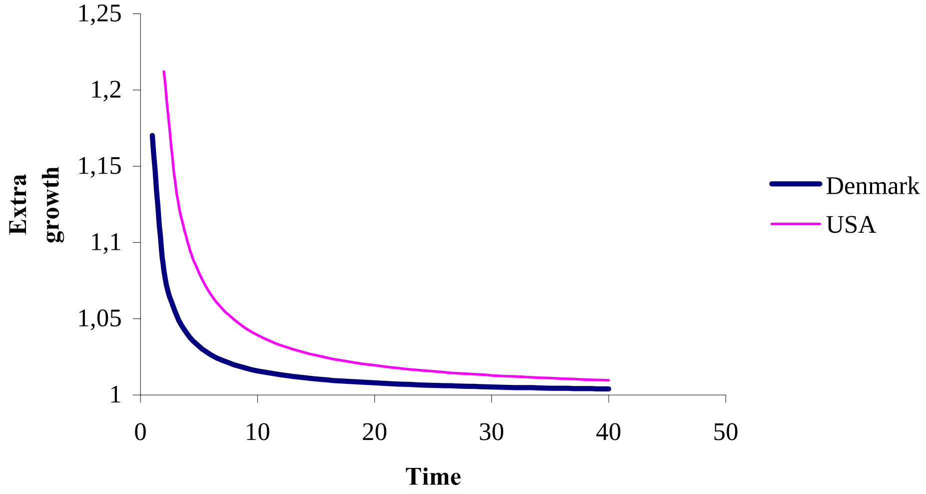
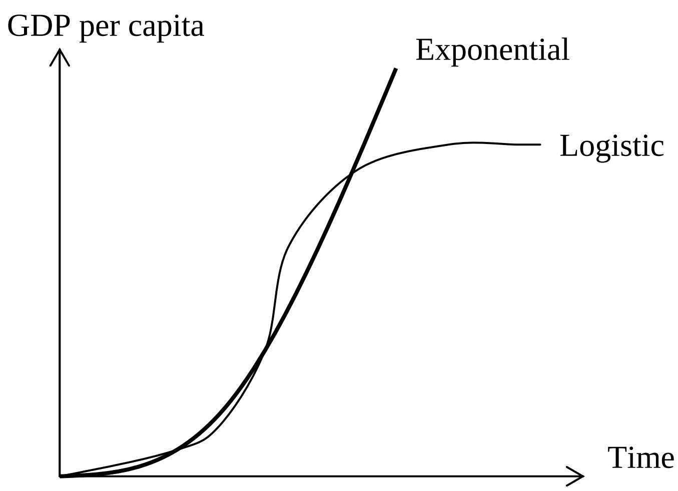


FIGURE 2.8

The exponential and the logistic function

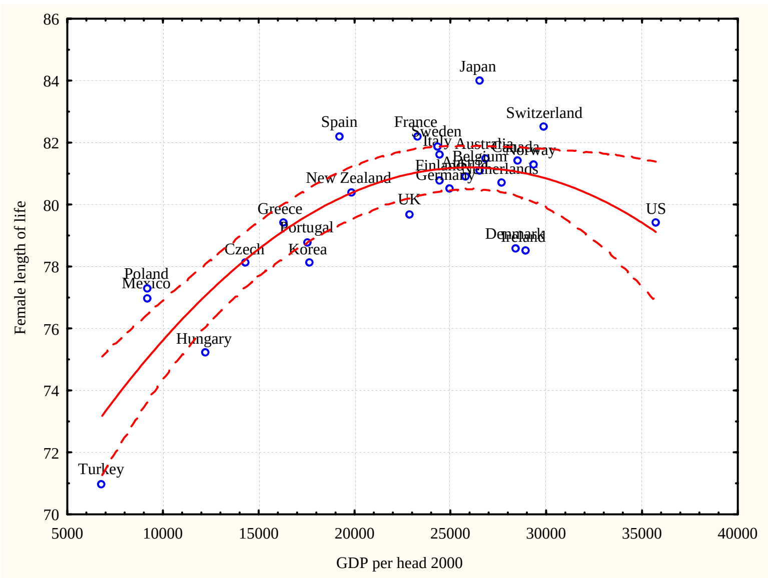


2.3 Welfare

Overall welfare is not equal to GDP per capita, even though these two concepts are clearly related. The level of welfare is a measure of several aspects of society. Expected length of life may be an additional social output worth considering, in addition to the value of production (Table 2.1). A welfare measure that disregards the negative aspects of the activities of society is biased towards the generations living now. If, for example, the amount of pollution is incorporated into the welfare measure, the focus shifts towards sustainable welfare production. In Figures 2.9-2.10 the length of life of females and males is related to GDP per capita.

FIGURE 2.9

Two welfare components: female length of life and GDP per capita in 2000

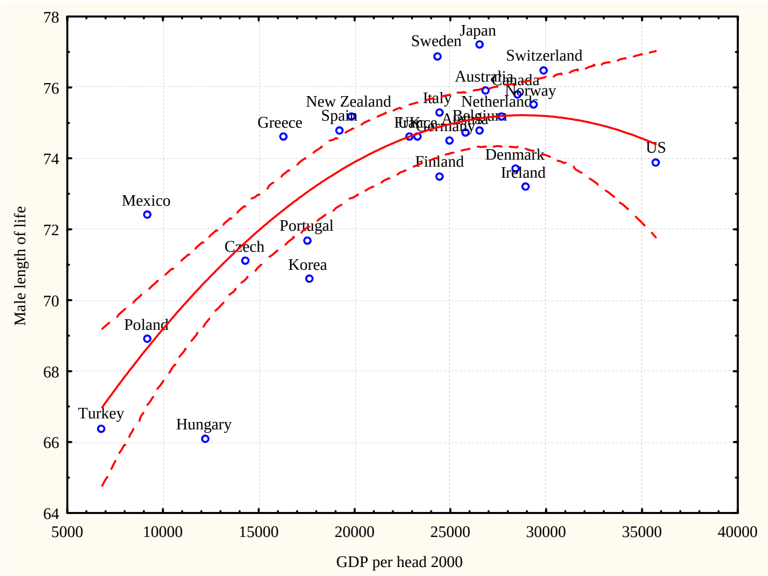


Source: OECD Statistics

We can see that Japan outperforms Sweden in both expected length of life and GDP per capita. An aggregate welfare measure (based on these two variables alone) ranks Japan ahead of Sweden, since Japan dominates Sweden in both respects. Moreover, the expected length of life in the US is shorter than in Sweden. Various welfare indices are introduced in Section 3.

FIGURE 2.10

Two welfare components: male length of life and GDP per capita in 2000



Source: OECD Statistics

2.4 Inputs

Sweden’s expenditure on R&D as a share of GDP exceeds the level in all other countries (Table 2.4). It should be noted that the same picture applies to many input variables and R&D expenditure is selected here as an example of an existing pattern. Even if US expenditure on R&D is relatively smaller, the absolute amount is very large. Moreover, the R&D expenditure per capita in the US exceeds the amount spent in any other country. Figure 2.11 relates GDP per capita to R&D expenditure (per cent of GDP) for all OECD countries except Luxembourg. Gross expenditure on R&D and business expenditure on R&D are proportionally high in Sweden, but the results on economic performance appear to be lacking. According to Ejermo (2002), productivity spill-over of R&D appears to be lacking in Sweden. However, he implies that spill-over effects exist abroad. See also Ministry of Finance (2000, p. 32). Moreover, it raises the issue of the focus of Sweden’s R&D expenditure.

TABLE 2.4

Research and Development indicators for OECD countries, 1997–1999

Country	GERD† %GDP	Country	BERD‡ %GDP	Country	GERD-BERD %GDP
Sweden	3.70	Sweden	2.77	Finland	0.95
Finland	3.09	Finland	2.14	Sweden	0.93
Switzerland	2.73	US	2.01	Austria	0.80
US	2.65	Switzerland	1.93	Japan	0.80
Korea	2.55	Korea	1.79	France	0.80
Germany	2.38	Germany	1.63	UK	0.77
France	2.17	France	1.37	Korea	0.76
Denmark	1.99	Belgium	1.31	Germany	0.75
Netherlands	1.95	Japan	1.30	Norway	0.73
Iceland	1.88	Denmark	1.26	Switzerland	0.72
Belgium	1.84	UK	1.20	US	0.72
UK	1.83	Netherlands	1.06	Australia	0.69
Japan	1.82	Austria	1.02	Denmark	0.68
Austria	1.82	Ireland	1.02	Netherlands	0.65
Norway	1.73	Canada	1.00	Belgium	0.64
Canada	1.58	Norway	0.98	Ireland	0.63
Australia	1.49	Czech Rep.	0.80	Iceland	0.62
Ireland	1.39	Iceland	0.76	Czech Rep.	0.60
Czech Rep.	1.27	Australia	0.67	Canada	0.60
New Zealand	1.13	Slovak Rep.	0.57	New Zealand	0.56
Italy	1.04	Italy	0.56	Slovak Rep.	0.54
Spain	0.90	Spain	0.46	Italy	0.48
Slovak Rep.	0.86	New Zealand	0.32	Portugal	0.46
Poland	0.75	Poland	0.31	Poland	0.44
Hungary	0.68	Hungary	0.27	Spain	0.44
Portugal	0.62	Turkey	0.16	Hungary	0.41
Greece	0.51	Portugal	0.14	Greece	0.37
Turkey	0.49	Greece	0.13	Turkey	0.36
Mexico	0.34	Mexico	0.07	Mexico	0.27

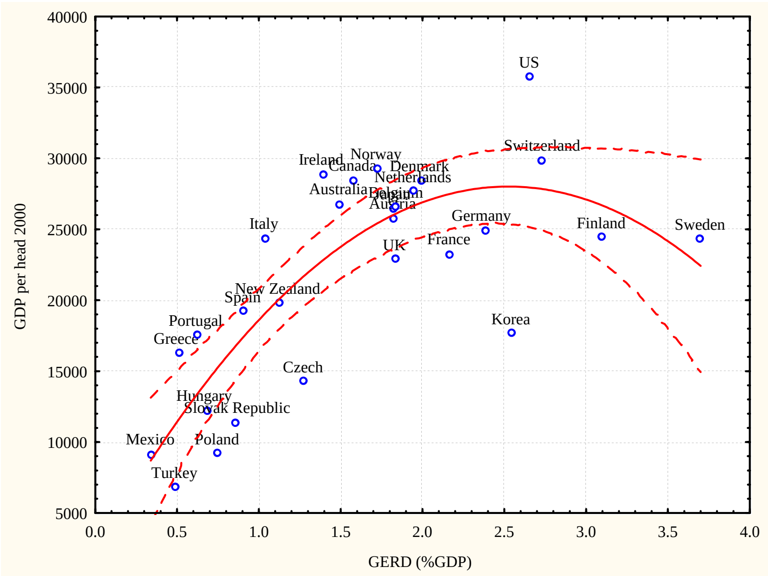
† Gross domestic expenditure on R&D.

‡ Business enterprise expenditure on R&D.

Source: OECD Statistics

FIGURE 2.11

A simple plot relating GDP per capita to GERD as a share of GDP



Source: OECD Statistics

GDP per capita can be broken down into average productivity and the average number of hours worked per capita. Figure 2.12 relates GDP per capita and GDP per hour. In a graph of this type, the slope of a straight line from the origin (not included in the figure) reflects the average number of hours worked per capita. Obviously, policies can target productivity as well as hours per capita. In Table 2.5 it can be seen that (on average) a person in Sweden works relatively few hours. Three recent studies of greater depth related to this issue are Gidehag and Öhman (2002), Jonasson and Pettersson (2002), and Lindh (2002).

The number of hours worked by a Swedish worker amounts to 67 per cent of the number of hours worked by a Korean worker. Moreover, a Swedish worker supplies 85 per cent of the number of hours supplied by a worker in the US. The relatively few working hours are compensated to some extent by the fact that a large share of the persons of working age are at work in Sweden. The number of hours worked by each person of working age in Sweden amounts to 78 per cent of the corresponding number in Iceland. Moreover, the number of hours spent at work by each person of working age in Sweden is 85 per cent of the number of hours spent at work in the US. Moreover, there are some demographic differences between the countries. The number of hours worked per person in the population is 73 per cent of the number of hours worked per person in the population in Korea. Also, the number of working hours per person in the population is 83 per cent of the number of working hours per person in the US.

Sweden, Norway and Denmark have a similar situation. The situation in Finland deviates from the situation in the other Nordic countries. In Finland, a worker works more hours (on average), but a smaller share of those of working age are at work. Moreover, the demographic structure in Finland differs somewhat.

Obviously, working so little per person reduces production and consumption per person. One extension of this line of argument is to calculate how many persons a worker has to support. The burden, $B = (1 - EL)/EL = 1/EL - 1$, decreases as the share of the population that is of working age, L, increases, and the share of those of working age that work, E, increases, i.e. $\partial B/\partial L < 0$ and $\partial B/\partial E < 0$.

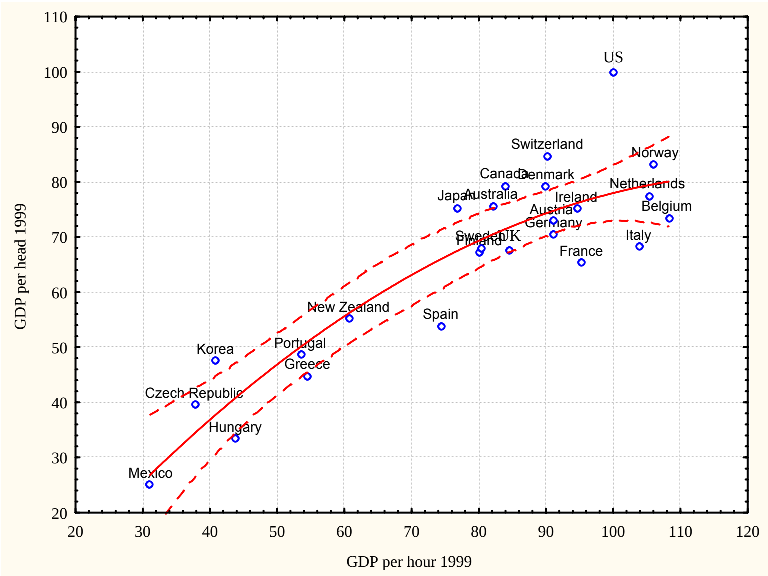
TABLE 2.5
Number of hours worked in 2000

Country	**Per worker**	**Country**	**Per person of working age**	**Country**	**Per person in population**
Korea	1.00	Iceland	1.00	Korea	1.00
Mexico	0.93	Korea	0.96	Iceland	0.94
Czech	0.87	US	0.92	Czech	0.89
Greece	0.83	Mexico	0.88	US	0.88
Japan	0.80	Czech Rep.	0.88	Japan	0.85
US	0.79	Japan	0.86	Canada	0.84
Spain	0.79	Canada	0.85	Switzerland	0.83
Australia	0.78	Switzerland	0.85	Australia	0.82
Ireland	0.78	Australia	0.84	Portugal	0.79
Hungary	0.77	New Zealand	0.80	Mexico	0.77
Canada	0.76	Portugal	0.80	Denmark	0.77
Iceland	0.76	Denmark	0.79	New Zealand	0.76
Portugal	0.75	Ireland	0.78	Ireland	0.76
New Zealand	0.73	Sweden	0.78	Finland	0.74
Finland	0.72	UK	0.78	UK	0.74
Italy	0.71	Finland	0.76	Sweden	0.73
Luxembourg	0.71	Norway	0.74	Greece	0.72
Belgium	0.71	Greece	0.73	Germany	0.70
France	0.69	Germany	0.71	Norway	0.69
UK	0.69	Luxembourg	0.70	Spain	0.68
Germany	0.68	Austria	0.70	Austria	0.68
Switzerland	0.68	Spain	0.69	Luxembourg	0.68
Sweden	0.67	Hungary	0.68	Hungary	0.68
Denmark	0.66	Netherlands	0.67	Netherlands	0.67
Austria	0.65	Belgium	0.67	Belgium	0.64
Norway	0.61	France	0.66	France	0.63
Netherlands	0.59	Italy	0.60	Italy	0.59

Source: OECD

FIGURE 2.12

GDP per hour and GDP per capita (1999)



Source: OECD Statistics

3 Results

The results based on cluster analysis are presented in Section 3.1. Data envelopment analyses (DEA) relating welfare to input are presented in Section 3.2. Aggregate measures of welfare components and inputs are analyzed per se and related to each other. The aggregate measures of inputs and welfare components are formed by taking averages of the indices included. In Appendices 4 and 5, the aggregate measures are estimated using weighted averages of the indices included. In Appendix 4 the applied weights originate from factor analysis. In Appendix 5 the weighting procedure forms entropy-like measures of welfare components and input factors.

3.1 Cluster analysis

The construction of the clusters is explained in Appendix 1.1. Cluster analysis can be performed using input indices only, welfare indices only, or both. Such analyses answer questions concerning potential welfare and realized welfare. Sweden is not included in a cluster using welfare indices (Figure 3.1) or using input indices (Figure 3.2). In other words, the Swedish mix of welfare components and input components differ from the situation in other countries. However, when both input and welfare indices are applied, Sweden is clustered together with Switzerland (Figure 3.3).

FIGURE 3.1

Cluster analysis based on the welfare indices I_Y (Income), I_M (Male life expectancy), I_F (Female life expectancy) and I_Z (Pollution)

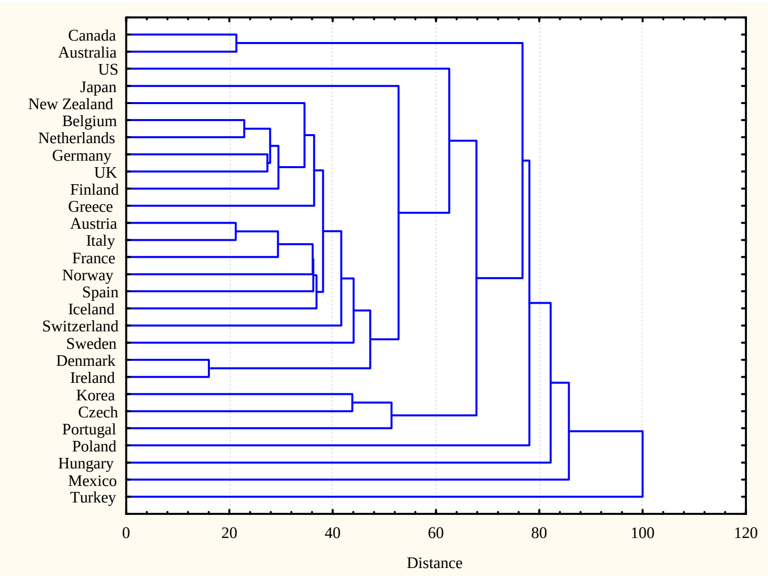


FIGURE 3.2

Cluster analysis based on the input indices I_L (Labor), I_H (Human capital), I_R (R&D) and I_I (Internet)

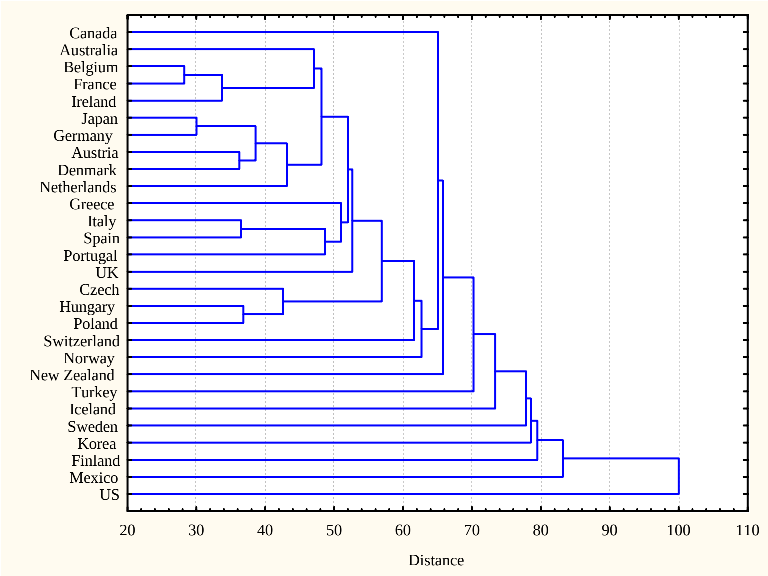
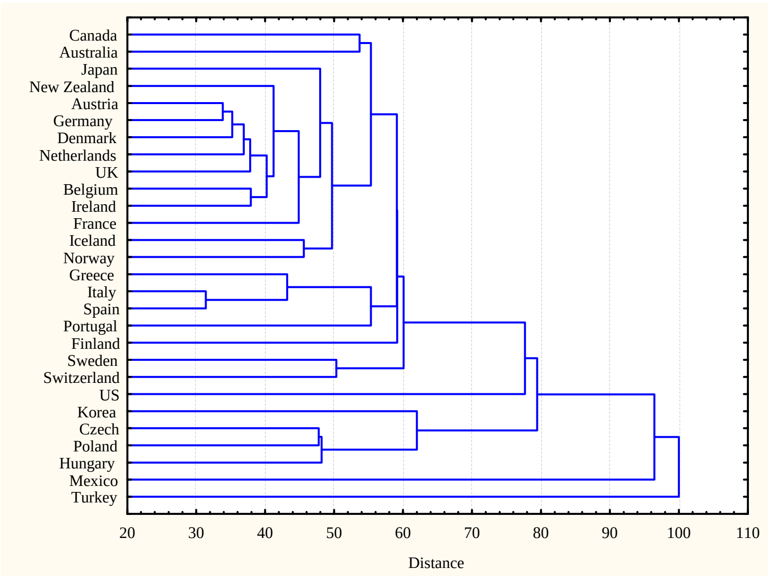


FIGURE 3.3

Cluster analysis based on the input and welfare indices I_L (Labor), I_H (Human capital), I_R (R&D), I_I (Internet), I_Y (Income), I_M (Male life expectancy), I_F (Female life expectancy) and I_Z (Pollution)



3.2 DEA using averages as measures of welfare and input

Often welfare is considered as being production alone. In this respect, it is clear that Sweden lags behind. This is clearly seen in Table 3.1, where a welfare index, $I_W(Y) = I_Y$, based solely on GDP per capita, Y, is presented. A ranking of countries using this welfare criterion gives Sweden a fairly high position (#16). The Swedish welfare index is only 61 per cent of the welfare index in the US. Note that both Luxembourg and the Slovak Republic have been removed from the analysis.

The second analysis incorporates GDP per capita, Y, the expected length of life for men, M, and women, F, respectively. The level of welfare in a country is calculated by the average of the included indices, i.e. $W = W(I_Y, I_M, I_F) = (I_Y + I_M + I_F)/3$. Moreover, this level of welfare is related to the maximum welfare obtained by a country, forming a welfare index, $I_W(Y, M, F)$. In this case, the Swedish welfare index is 90 per cent of the welfare index in Japan. Moreover, the Swedish welfare index is above the welfare index in the US, due to the fact that the expected length of life is shorter in the US. Observe that by using two indices for length of life, one for men and one for women, the importance of this variable for welfare may be exaggerated.

TABLE 3.1

Welfare ranking using economic and health indicators in 2000

Country	$I_W(Y)$ (%)	Country	$I_W(Y, M, F)$ (%)
US	100	Japan	100
Switzerland	80	Switzerland	98
Norway	78	Iceland	94
Ireland	76	Canada	90
Canada	75	Norway	90
Denmark	75	Sweden	90
Netherlands	72	Australia	89
Iceland	72	US	88
Australia	69	Netherlands	85
Belgium	68	Italy	84
Japan	68	Belgium	84
Austria	66	France	82
Germany	63	Austria	82
Finland	61	Germany	79
Italy	61	Spain	77
Sweden	61	Finland	76
France	57	Denmark	75
UK	56	New Zealand	74
New Zealand	45	UK	74
Spain	43	Ireland	74
Korea	37	Greece	65
Portugal	37	Portugal	55
Greece	33	Korea	49
Czech Rep.	26	Czech Rep.	47
Hungary	19	Mexico	41
Poland	8	Poland	31
Mexico	8	Hungary	19
Turkey	0	Turkey	1

A third analysis also incorporates the amount of pollution (CO_2 emissions) (Table 3.2). In this case, the level of welfare in a country is expressed as $W = W(I_Y, I_M, I_F, I_Z)$, which is transformed into a welfare index, $I_W(Y, M, F, Z)$ as described above. In this version, the Swedish welfare index is 94 per cent of the Swiss welfare index. US and Japan fall in the ranking, since they are relatively large polluters.

Moreover, use of the logarithm of GDP per capita, $\ln Y$, gives a Swedish welfare index equal to 97 per cent of the welfare index in Switzerland (Table 3.2). By using logarithms, the importance of income is reduced. Some persons argue that the welfare effect of a marginally increased economic standard diminishes with the level of economic standard, in contrast, for example, to the welfare effect of marginally increased life expectancy. However, such transformations may be questioned, since the importance of income may be reduced too much.

TABLE 3.2

Welfare ranking using economic and health indicators in 2000

Country	$I_W(Y, M, F, Z)$ **(%)**	**Country**	$I_W(\ln Y, M, F, Z)$ **(%)**
Switzerland	100	Switzerland	100
Japan	95	Sweden	97
Sweden	94	Japan	96
Iceland	93	Iceland	94
Norway	89	France	89
France	87	Norway	89
Italy	86	Italy	88
US	85	Austria	86
Austria	84	Spain	85
Spain	81	US	83
Netherlands	80	Netherlands	82
New Zealand	77	New Zealand	80
Belgium	77	Germany	79
Germany	76	Belgium	79
UK	75	UK	78
Denmark	73	Denmark	75
Canada	73	Canada	74
Finland	71	Finland	74
Ireland	71	Greece	74
Greece	70	Ireland	72
Australia	70	Australia	72
Portugal	66	Portugal	69
Mexico	60	Mexico	61
Korea	56	Korea	60
Czech Rep.	49	Czech Rep.	53
Poland	42	Poland	44
Hungary	38	Hungary	42
Turkey	30	Turkey	29

The result is that Sweden is ranked higher among OECD countries when an extended welfare measure is applied. It may appear that this diminishes the importance of the relatively low GDP per capita in Sweden. However, a conclusion of this type is incorrect. It simply means that policies need to focus on health and environment in addition to production. The bottom line is that, regardless of the actual rating, things can always be improved. It is obvious that production in Sweden is substantially smaller in relative terms than in many other OECD countries, including Norway and Denmark. Moreover, it is probably easier to improve in areas where performance is relatively poor.

According to the Human Development Index, *HDI*, presented by UNDP (2002), Sweden is ranked second, after Norway. The Human Development Index is a measure that combines expected length of life, education, and the logarithm of GDP. In Table 3.3 we present the *HDI* according to UNDP, and a recalculated measure using GDP per capita per se. The result is not that favorable to Sweden. The rating drops from 2^{nd} to 13^{th} place. In the UNDP study it can be clearly seen that (overall) the life expectancy index, education index, and the GDP index are highly correlated. Moreover, Maddison (2001, page 29) writes that “there has been significant congruence, over time and between regions, in the patterns of improvement in per capita income and life expectation”. How can any aspects of welfare be maintained with small production? In other words, it may be difficult to sustain the current level of welfare in Sweden. In the rest of this paper GDP per capita is not logged. Taxes on economic activity pay for the welfare system, not taxes on the logarithm of economic activity.

TABLE 3.3
Welfare ranking using economic and health indicators in 2000

Country	*HDI* (%)	Country	Adjusted *HDI* (%)
Norway	94.2	US	90
Sweden	94.1	Norway	87
Canada	94.0	Iceland	87
Belgium	93.9	Canada	86
Australia	93.9	Ireland	86
US	93.9	Belgium	85
Iceland	93.6	Switzerland	85
Netherlands	93.5	Australia	84
Japan	93.3	Japan	84
Finland	93.0	Netherlands	84
Switzerland	92.8	Denmark	84
France	92.8	Austria	84
UK	92.8	Sweden	84
Denmark	92.6	Finland	83
Austria	92.6	Germany	83
Germany	92.5	France	82
Ireland	92.5	UK	82
New Zealand	91.7	Italy	81
Italy	91.3	New Zealand	79
Spain	91.3	Spain	78
Greece	88.5	Greece	74
Korea	88.2	Korea	74
Portugal	88.0	Portugal	74
Czech Rep	84.9	Czech Rep.	69
Hungary	83.5	Hungary	67
Poland	83.3	Poland	66
Mexico	79.6	Mexico	62
Turkey	74.2	Turkey	56

In Figure 3.4 the UNDP *HDI* index is broken down into one part originating from education and expected length of life, and one part from income. Note that the UNDP takes logarithms of the income measure but, in Figure 3.4, income is used per se. In Figure 3.5 the welfare index $I_W(Y,M,F,Z)$ is broken down into one part originating from expected length of life and environmental concern, and one part from income. To a (relatively) large extent, the Swedish welfare stems from expected length of life and environmental concern and, to a (relatively) smaller extent, from GDP per capita (Figure 3.5). The reverse situation is true of the US. Moreover, increased GDP per capita increases welfare. In addition, increased GDP per capita makes other goals easier to maintain, i.e. good health care, schools, publicly funded R&D.

FIGURE 3.4

The UNDP human development index, broken down. The UN Life Expectancy Index and UN Education Index are labeled UNLI, UNEI, respectively. The welfare originating from life expectancy and education, $1/3(UNLI + UNEI)$, is measured on the y-axis. The welfare created by income, $YI/3$, is measured on the x-axis

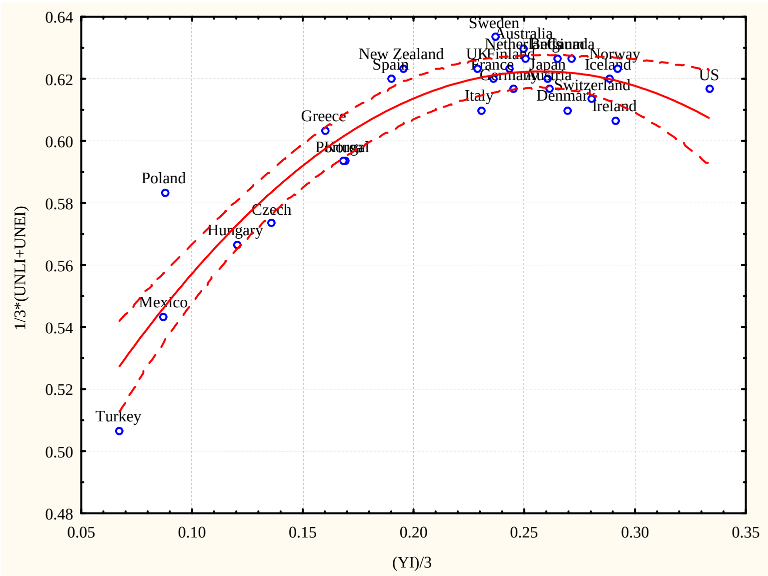
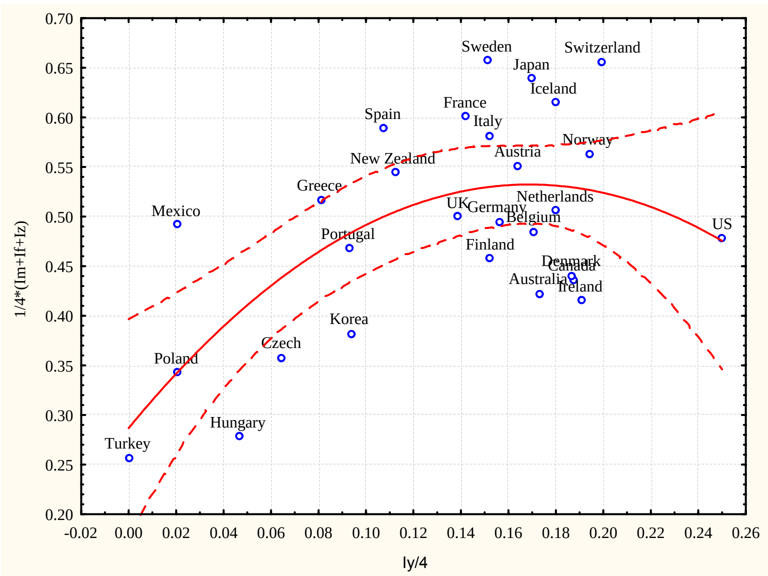


FIGURE 3.5

The welfare index, $I_W(Y, M, F, Z)$, broken down. The welfare originating from male and female life expectancies, and (low) pollution, $1/4(I_M + I_F + I_Z)$, is measured on the y-axis. The welfare derived from income, $I_Y/4$, is measured on the x-axis



Welfare is created by life expectancy, GDP per capita and environmental concern. In other words, by calculating a welfare index, $I_W(Y, M, F, Z)$, it is implied that the components included in the index are interchangeable. The marginal rate of substitution can be calculated between pairs of welfare components. One per cent of the maximum difference in GDP per capita and one per cent of the maximum difference in expected length of life are equal in welfare terms, since the welfare index is an average of the indices included. One per cent of the maximum difference in GDP per capita is $289 and one per cent of the maximum difference in expected length of life is 0.111 years and 0.13 years for men and women, respectively. In welfare terms, an extra year in average length of life for men and women is equal to $(289/0.111 \approx)$ $2,604 and $(289/0.13 \approx)$ $2,223 less in GDP per capita, respectively.

The welfare indices for Switzerland and Sweden are 0.855641 and 0.808335, respectively. The estimated difference in welfare is 0.047306. If GDP per capita in Sweden were 22 per cent higher, the welfare level would equal the welfare level in Switzerland (assuming no changes in other welfare components), since $4(0.047306)28{,}899 / 24{,}309 \approx 0.22$.

In Figure 3.6, the GDP per capita index, I_Y, is related to the labor index, I_L. Mexico, Norway and US are efficient. Sweden is located below the best practice graph. Hence, Sweden is using its potential labor force inefficiently. Efficiency is measured as either the horizontal distance or the vertical distance (in relative terms) to the best practice graph (Appendix 1.3). It can be seen that many countries have a higher GDP per capita index than Sweden. However, these countries all have a higher labor index. Persons of working age either study, work, are unemployed, sick, or are in early retirement. The persons that are working have a certain amount of real capital for their production. Moreover, social capabilities are also important (Abramovitz, 1995). Workers in Sweden can use a lot of machines (including computers) and be highly educated, but so can workers in other countries. Note that the productivity of Swedish workers (on average) is not exceptional (Figure 2.12).

Convergence and divergence in GDP per capita can be visualized as vertical movements in Figure 3.7. A vertical movement may be due to changing production techniques. For example, Poland is most likely to move upwards in the years to come, due to the introduction of market economy, competition, foreign investments, trade, and so on. Moreover, policies may affect the share of the potential labor force that is employed. Note that Sweden may benefit, i.e. move upwards, from exactly the same types of policies.

A horizontal movement in Figure 3.7 is due to changes in the share of population of working age. In the case of an ageing population in Europe, convergence towards the current Swedish labor index can be expected. However, the Swedish population will continue to get older (on average). In the near future, a lot of people will retire in Sweden. The ageing of the population affects growth negatively (Ministry of Finance, 2000, p. 28). This resembles the situation in Sweden in the 19th century when a lot of persons emigrated.

FIGURE 3.6

The best practice graph relating the labor input index, I_L, and the GDP per capita index, I_Y, based on the variable returns to scale assumption

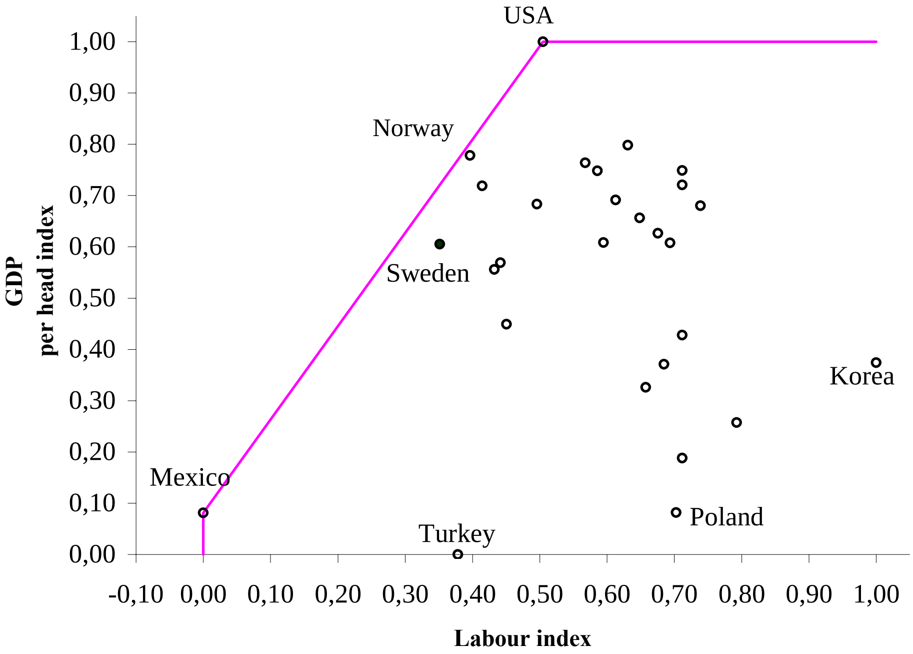
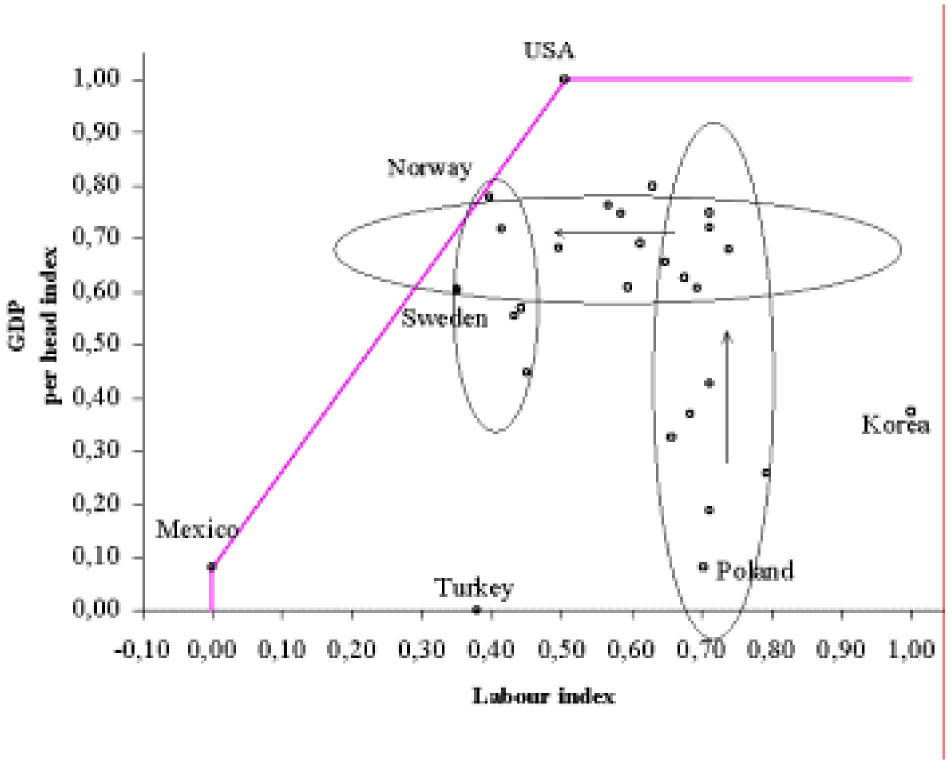


FIGURE 3.7

Horizontal and vertical convergence



The low labor index may be countered by more of other inputs. It should be observed that technology is transferred between countries, so there is no clear advantage in having a low labor index. A country with a low labor index, such as Sweden, cannot be expected to produce more (per person in the population) than other countries, i.e. have a relatively high GDP per capita index. Moreover, the estimated aggregate measure of inputs is related to the maximum value, creating an overall input index (Table 3.4).

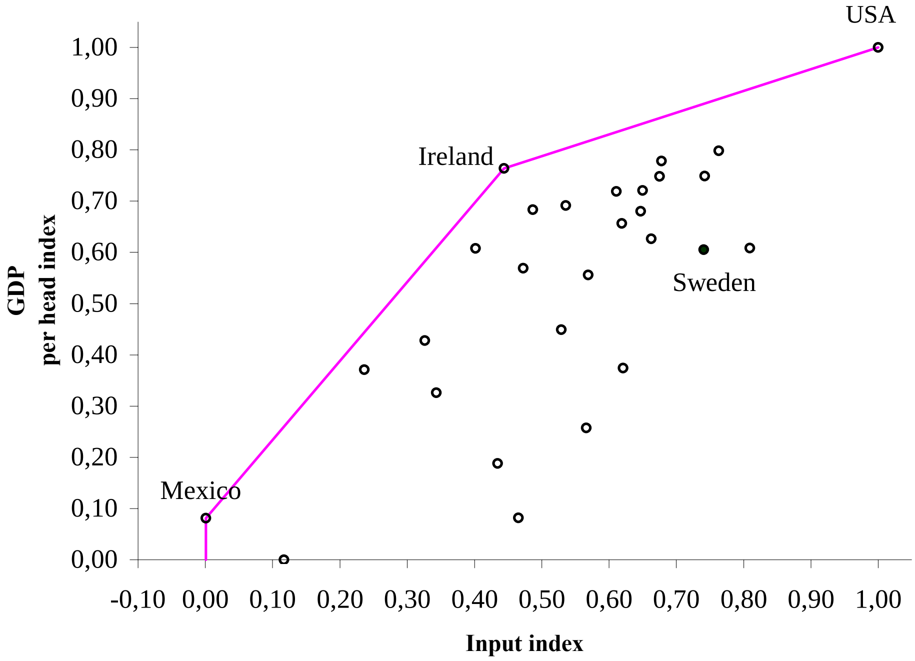
TABLE 3.4
Input index, 2000

Country	$I_X(L,H,R,I)$ **(%)**
US	100
Finland	81
Switzerland	76
Canada	74
Sweden	74
Norway	68
Denmark	67
Germany	66
Netherlands	65
Japan	65
Korea	62
Austria	62
Iceland	61
UK	57
Czech Rep.	57
Australia	54
New Zealand	53
Belgium	49
France	47
Poland	47
Ireland	44
Hungary	43
Italy	40
Greece	34
Spain	33
Portugal	24
Turkey	12
Mexico	0

This aggregate input index is related to the GDP per capita index, I_Y, in Figure 3.8. Mexico, Ireland, and US are efficient. Moreover, it is evident that GDP per capita in Sweden is low, in relation to the inputs available. Remember that all countries with a higher GDP per capita index than Sweden also have a higher labor index (Figure 3.6).

FIGURE 3.8

The best practice graph relating the aggregate input index, $I_X(L,H,R,I)$, and the income index, I_Y, based on the variable returns to scale assumption



In Figure 3.9, the input index, $I_X(L,H,R,I)$, is related to the welfare index, $I_W(Y,M,F,Z)$. Mexico, Spain, Italy, France, Iceland, Japan, and Switzerland are the efficient countries. All other countries are below the best practice graph. Sweden has a relatively high input index, since its low labor index is compensated by large higher education, R&D, and Internet indices. Sweden has a relatively high welfare index, since its low GDP per capita index is compensated by high expected length of life and emission indices. However, it can be questioned whether a situation of this type is sustainable. The inefficient production of welfare in Sweden means that either the actual level of welfare could be achieved with fewer inputs, or the welfare achieved could be higher given the input. Japan and Switzerland are the two countries that Sweden is related to, i.e. they are our benchmark countries. The best practice graph for these countries has overall decreasing returns to scale.

The efficiency scores are presented in Table 3.5. Note that the estimated efficiency parameters are transformed (the transformation procedure is explained in Appendix 3). Efficiency parameters could have been estimated for all other combinations of indices as well. However, in the present case, the Swedish welfare index could be three per cent higher or the actual welfare index could be achieved with an input index at 90 per cent of the current input index. The Swedish level of welfare could be increased by one per cent. Alternatively, the actual level of welfare could be achieved with three per cent less input. Moreover, France is efficient in the production of welfare, given the relatively low level of input used. Nonetheless, France is far behind Switzerland in the welfare index, but this may be explained by lack of inputs. Moreover, Denmark and Finland are really performing poorly.

In addition, Sweden manages to attain a very high welfare index, $I_W(Y,M,F,Z)$, with the limited labor index, I_L (Figure 3.10). In this case Mexico, Sweden and Switzerland are efficient. Once again, it is difficult not to question the long-term stability of this situation.

FIGURE 3.9

The best practice graph relating the average input index, $I_X(L,H,R,I)$, and the average welfare index, $I_W(Y,M,F,Z)$, based on the variable returns to scale assumption

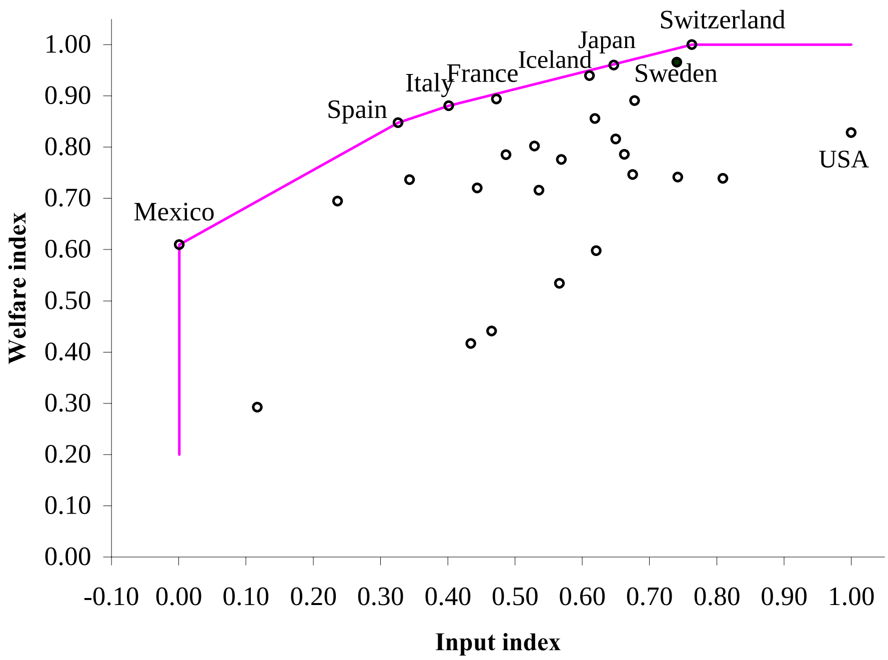


FIGURE 3.10

The best practice graph relating the labor index, I_L, and the average welfare index, $I_W(Y, M, F, Z)$, based on the variable returns to scale assumption

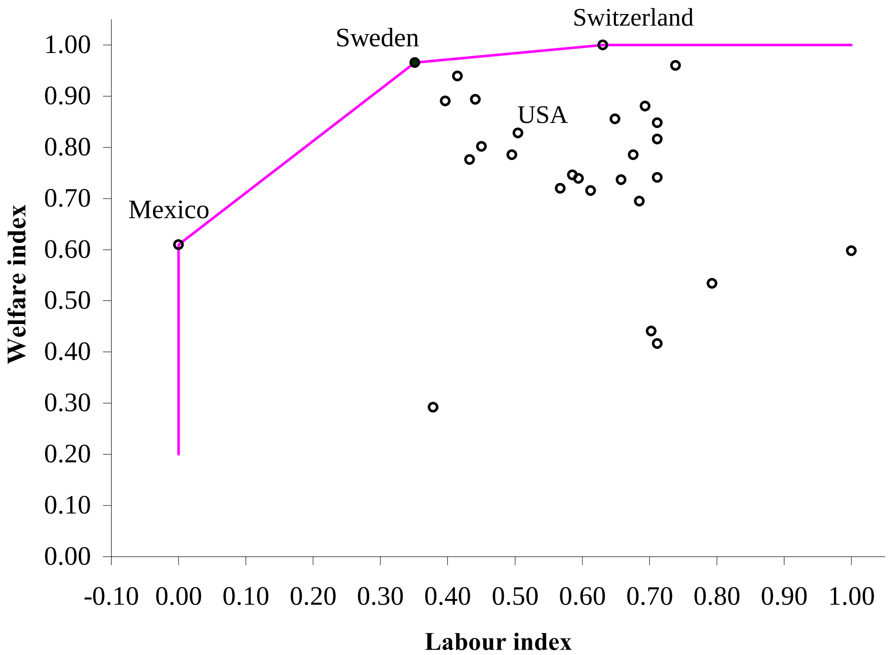


TABLE 3.5

The output and input efficiency scores for the year 2000 based on the average welfare index, $I_W(Y,M,F,Z)$, and input index, $I_X(L,H,R,I)$. The output efficiency score measures how much (in relative terms) an efficient usage of the input index would increase the welfare index (Appendix 1.3). The input efficiency score measures the share of the actual input index that would produce the welfare index if used efficiently (Appendix 1.3). Moreover, the adjusted output and input efficiency scores are the corresponding measures expressed in the level of the included variables (Appendix 3)

Country	Output efficiency $(1-\theta)/\theta$ (%)	Adjusted output efficiency $(1-\theta^*)/\theta^*$ (%)	Country	Input efficiency λ	Adjusted input efficiency λ^*
Switzerland	0	0	France	1.00	1.00
Mexico	0	0	Iceland	1.00	1.00
France	0	0	Italy	1.00	1.00
Iceland	0	0	Japan	1.00	1.00
Spain	0	0	Mexico	1.00	1.00
Japan	0	0	Spain	1.00	1.00
Italy	0	0	Switzerland	1.00	1.00
Sweden	3	1	Sweden	0.90	0.97
Norway	9	2	Portugal	0.50	0.94
Portugal	13	2	Turkey	0.01	0.93
Austria	10	2	Greece	0.51	0.92
New Zealand	14	3	Norway	0.67	0.90
Belgium	14	3	Belgium	0.50	0.89
Greece	16	3	Austria	0.56	0.88
Netherlands	18	3	New Zealand	0.50	0.88
UK	19	3	Ireland	0.34	0.86
Ireland	23	4	UK	0.40	0.85
Germany	23	4	Netherlands	0.44	0.84
US	21	4	Australia	0.27	0.82
Australia	28	4	Germany	0.36	0.82
Denmark	30	5	Denmark	0.28	0.79
Canada	34	6	Hungary	0.00	0.79
Finland	35	6	Poland	0.00	0.78
Korea	58	8	Canada	0.24	0.77
Czech Rep.	73	9	Czech Rep.	0.00	0.74
Turkey	138	11	Finland	0.22	0.74
Poland	102	11	US	0.30	0.74
Hungary	113	12	Korea	0.00	0.73

4 Policy conclusions and suggestions for future research

At present, the Swedish population does not have a high economic standard (in relative terms). However, the situation seems significantly better when broader measures of welfare are used. Life expectancy, literacy, educational attainment, and a clean environment are relatively important sources of Sweden's welfare index. In other words, a relatively small share of the welfare is derived from economic activities. It is highly probable that Sweden's historically good economic performance (in relative terms) has been essential for the good performance shown in the welfare indicators of today. Hence, the long-term stability of the situation may be questioned. The definition of a welfare measure is by no means obvious. To some extent, the results depend on the procedures used for calculations, and politicians (and implicitly the whole population) may benefit from a better understanding of these issues. To be specific, we argue against transformations that reduce the welfare effect of income too much.

How may welfare be increased? The room for improvement is probably largest where production is concerned, since Sweden performs relatively better in all other areas. Moreover, future demographic trends constitute a political challenge, since they put the welfare system under stress. The possibility of supplying public health care, public schools, publicly funded R&D, law and order and so on may be reduced in the near future, unless production grows. Nonetheless, policies that target a relatively clean environment and information concerning smoking, drinking and so on are important for maintaining the level of welfare.

How may production be increased? Sweden lacks persons of working age (16-64), which is the selected measure of the potential labor force. It is an erroneous conclusion that (relatively) low labor input can be compensated, fairly easily and fully, by other inputs, since a strategy of this type may be applied in all countries. In other words, economic convergence between countries with very different demographic situations cannot be expected. In the Swedish situation, a solution may be to extend working life beyond the age of 65, particularly since Swedish R&D expenditure and higher education indices are already high. Immigration as a solution is addressed in Rauhut (2002a, 2002b).

The share of those people of working age that actually work may be increased, since unemployment and sickness can be targeted. The present problem of absence due to sickness may be an indication of the necessary balance between economic resources and social welfare. Moreover, many retire before the age of 64, and raising the average retirement age is a highly relevant policy ambition. The potential existing in earlier entry into the labor market should be observed, for example via shortened average university studies. By increasing the participation rate, the total number of working hours may be increased.

Productivity may be increased by investments in physical capital, and policies may target foreign and domestic investments. Moreover, policies ought to acknowledge the importance of accessibility to jobs, workers, markets, and so on. Infrastructure investments, developing the usage of ICT and more flexible forms for working may have a positive effect on many forms of interaction. In addition, the globalization process may increase the degree of competition and eliminate local monopolies.

Hence, policies may increase the efficiency of economic activities in Sweden. The incentive structure is a key instrument for many of the identified policy targets. The historically slow growth from 1970 may be related to the structure of economic incentives. The importance of incentives is stressed in, for example, Gidehag and Öhman (2002).

A very relevant extension to this paper is an analysis over time. Two options exist. Either data for earlier periods should be collected or data in forthcoming periods should be gathered. When data of this type exist, other forms of analysis could be used. The analysis of the phenomena of growth of production and welfare could then be addressed both in a static mode over time and in a dynamic approach per se.

Other data may be incorporated into the analysis. For example, the amount of physical capital can be added, when data of this type are available. Moreover, some other measure of effects on the environment may be used.

In this study, different weight structures have been applied to form aggregate input and welfare indices. An alternative way of specifying a certain weight structure is to assign weights randomly. If this is repeated, for example 10,000 times, a picture of the most likely ranking of countries can be expected to emerge. Such analyses are interesting extensions of this work.

References

Andersson, T., 2002, *Politik för tillväxt – Internationella trender och den svenska utmaningen*, A2002:007, ITPS, Östersund.

Abramovitz, M., 1995, The Elements of Social Capability, in Koo, B. H., and Perkins, D. H. (Eds.), 1995, *Social Capability and Long-Term Economic Growth*, Macmillan Press, Basingstoke, 19-46.

Berger-Schmitt, R., and Jankowitsch, B., 1999, *Systems of Social Indicators and Social Reporting: The State of the Art*, EuReporting Working Paper No. 1, Centre for Survey and Research and Methodology, Mannheim.

Berger-Schmitt, R., 2001, *Dimensions, Indicators and Time Series in a European System of Social Indicators by Example*, EuReporting Working Paper No. 16, Centre for Survey and Research and Methodology, Mannheim.

Berger-Schmitt, R., and Noll, H.-H., 2000, *Conceptual Framework and Structure of a European System of Social Indicators*, EuReporting Working Paper No. 9, Centre for Survey and Research and Methodology, Mannheim.

Berger-Schmitt, R., 2002, Unterschiede in den Lebensbedingungen innerhalb der Europäischen Union kaum verringert, *Informationsdienst Soziale Indikatoren 27*, 1-5.

Calmfors, L., and Persson, M. (Eds.), 1999, *Tillväxt och ekonomisk politik*, Studentlitteratur, Lund.

Ejermo, O., 2002, *Productivity Spillovers of R&D in Swedish Industries and Firms*, Presented at the Uddevalla Symposium.

Gidehag, R., and Öhman, H, 2002, *Använd kraften! Vägar till ett större arbetsutbud*, Reforminstitutet, Stockholm.

Färe, R., Grosskopf, S. and Lovell, C.A.K., 1994, *Production Frontiers*, Cambridge University Press, Cambridge.

Färe, R., and Grosskopf, S., 1996, *Intertemporal Production Frontiers: With Dynamic DEA*, Kluwer, Dordrecht.

Førsund, F., and Hjalmarsson, L., 1987, *Analyses of Industrial Structure, A Putty-Clay Approach*, The Industrial Institute for Economic and Social Research, Stockholm.

Henrekson, M., 1992, *Sveriges Tillväxtproblem, En analys med särskild tonvikt på humankapitalets roll*, SNS förlag, Stockholm.

Henrekson, M, 2001, Swedish Economic Growth and Scholarly Objectivity, An objective sociologist vs. subjective economists, or the other way around? *Challenge*, 38-58.

Jonasson, E., and Pettersson, L., 2002, *Employment and Non-Employment, A Study of the Swedish Labor Market*, unpublished working paper, Jönköping Business School.

Jones, C. I., 2002, Sources of U.S. Economic Growth in a World of Ideas, *American Economic Review*, 1, 220-239.

Korpi, W., 1991, Halkar Sverige efter? Vår ekonomiska tillväxt och produktivitet i jämförande belysning, in Norén, R. (Ed.), 1991, *Struktur och tillväxt*, SNS, Stockholm, 89-104.

Korpi, W., 2000, Welfare States, Economic Growth, and Scholarly Objectivity, *Challenge,* 42, 49-66.

Landau, R., Taylor, T., and Wright, G., 1996, *The Mosaic of Economic Growth,* Stanford University Press, Stanford.

Lindbeck, A., 2000, Swedish Economic Growth in an International Perspective, *Swedish Economic Policy Review,* 7-37.

Lindbeck, A., 2002, *Sverige är inne i en ond cirkel,* Dagens Nyheter, Stockholm.

Lindh, T., 2002, *Befolkningen, familjen och ekonomisk tillväxt,* ITPS, VINNOVA and NUTEK, Stockholm.

Maddison, A., 2001, *The World Economy, A Millennial Perspective,* OECD, Paris.

Nicoletti, G., Scarpetta, S., and Boylaud, O., 2000, *Summary Indicators of Product Market Regulation with an Extension to Employment Protection Legislation,* Economics Department Working Paper No. 226, OECD.

Rauhut, D., 2002a, *Arbetskraftsbrist och arbetskraftsinvandring, Hot eller möjlighet för ekonomisk tillväxt?,* A 2002:010, ITPS, Östersund.

Rauhut, D., 2002b, *Var hittar Sverige sin arbetskraft? En översikt av tänkbara sändarländer,* A 2002:13, ITPS, Östersund.

SNS konjunkturråd, 1991, Sveriges tillväxt. Replik till Korpi, in Norén, R. (Ed.), 1991, *Struktur och tillväxt,* SNS, Stockholm, 105-110.

StataCorp, 2001, *Stata Reference Manual: Release 7,* Stata Press, College Station, Texas.

Svedberg, P., 1999, Vad bestämmer skillnader i tillväxt mellan länder?, in Calmfors, L., and Persson, M. (Eds.), *Tillväxt och ekonomisk politik*, Studentlitteratur, Lund, 71-102.

The Economist, 2002, *Demography and the West*, August 24th-30th, 20-22.

The Ministry of Industry, Employment, and Communications, Näringsdepartementet, 2002, *Benchmarking av näringspolitiken 2002,* Ds 2002:20, Fritzes, Stockholm.

The Ministry of Finance, Finansdepartementet, 2000, *Långtidsutredningen 1999/2000,* SOU 2000:7, Fritzes, Stockholm.

UNDP, 2002, *Human Development Report 2002, Deepening democracy in a fragmented world,* United Nations Development Programme, New York.

Wallen, F., 2002, *Tillväxtgapet, Tillväxtens utveckling i Sverige respektive Danmark 1970-2000*, Svenskt Näringsliv, Stockholm.

OECD, 1997, *Flows and Stocks of Fixed Capital,* OECD, Paris.

OECD, 2001a, *OECD Employment Outlook*, June 2001, OECD, Paris.

OECD, 2001b, *OECD Economic Outlook*, Volume 2001/2, No. 70, OECD, Paris.

OECD, 2001c, *Basic Science and Technology Statistics*, OECD, Paris.

OECD, 2001d, *Education at a Glance, OECD Indicators*, OECD, Paris.

OECD, 2001e, *The New Economy Beyond the Hype*, The OECD Growth Project, OECD, Paris.

OECD, 2001f, *Measuring Capital, OECD Manual, Measurement of Capital Stocks, Consumption of Fixed Capital and Capital Services*, OECD, Paris.

OECD, 2001g, *Measuring Productivity, Measurement of Aggregate and Industry-level Productivity Growth*, OECD, Paris.

OECD, 2002a, *National Accounts of OECD Countries, -Main Aggregates, Volume 1, 1989-2000,* OECD, Paris.

OECD, 2002b, Purchasing Power Parities - Measurement and Uses, *Statistics Brief No. 3,* OECD, Paris.

Ohlsson, R., 1998, Generations- och könsaspekter på det svenska välfärds-samhällets framväxt, in Persson, I., and Wadensjö, E., 1998, *Välfärdens Genusansikte*, SOU 1998:3, Fritzes, Stockholm.

RoD, 2002, Välfärd trots sämre tillväxt, *Från Riksdag & Departement,* 32.

Öckert, B., 2002, *Do University Enrollment Affect Education and earnings?,* Working Paper 2002:16, Institute for Labor Market Policy Evaluation, Uppsala.

Other references

Statistica 6.0, Electronic Manual.

Appendix 1 Method

This appendix has three subsections. Clustering is presented in Appendix 1.1, factor analysis in Appendix 1.2, and data envelopment analysis in Appendix 1.3.

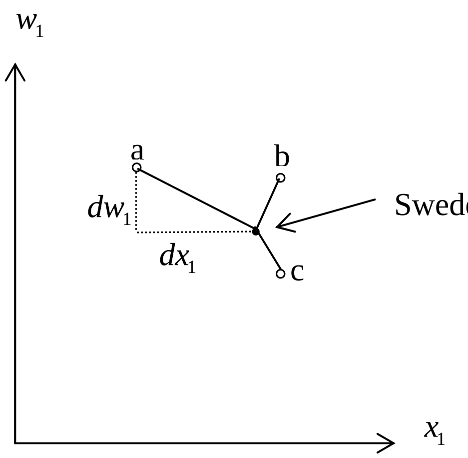
Appendix 1.1 Clustering

A country can be characterized in many ways. Broadly, descriptive variables can be classified as being either input or output. Given a number of characteristics, one may ask which countries are the most similar to a specific country. It is possible to combine all (chosen) characteristics into measures of dissimilarity between countries. Calculations of this type may be performed using input variables only, output variables only, or both.

To illustrate clustering, assume that we only investigate one output and one input. Plotting the pairs (x_1, w_1) for the chosen number of countries will produce a picture like that in Figure A1.1. There are several ways to construct measures of dissimilarity. We use the Euclidean distance measure, defined as $E = \sqrt{(dw_1)^2 + (dx_1)^2}$. In Figure A1.1 country c is identified as being closest to Sweden in characteristics x_1 and w_1, since the connecting line is the shortest. For a discussion of alternative dissimilarity measures, see StataCorp (2001).

FIGURE A1.1

The Euclidean distance measure, between Sweden and three other countries labeled a, b and c



Appendix 1.2 Factor analysis

Factor analysis is a statistical technique used to identify groups of variables. A group consist of variables with strong relations. The groups are the main components of the constructed factors. The procedure is described in more detail in StataCorp (2001) and Statistica 6.0 Electronic Manual. The main applications of factor analytic techniques are: (1) to reduce the number of variables included in an analysis and (2) to detect relationships between variables, i.e. to classify variables.

Appendix 1.3 Data Envelopment Analysis

This section presents methods that are part of a wide field that is exemplified by Førsund and Hjalmarsson (1987), Färe, Grosskopf and Lovell (1994), and Färe and Grosskopf (1996).

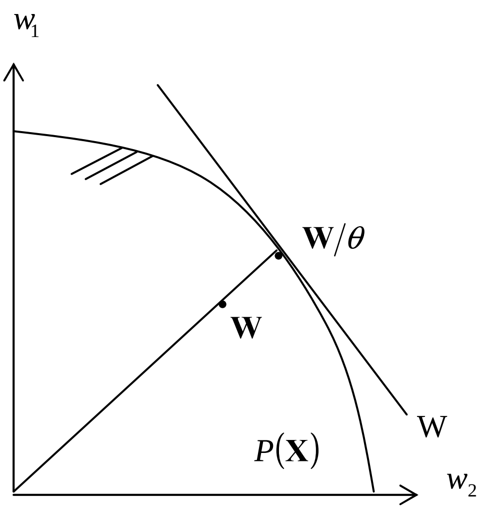
With the input vector, $\mathbf{X}$, a country produces the output vector, $\mathbf{W}$. In Figure A1.2 the efficiency concept is graphically illustrated, using an output vector in two dimensions. All different output vectors that can be produced with the input vector making the output set, $\mathbf{P}(\mathbf{X})$. The radial expansion of actual production, $\mathbf{W}$, to the best practice frontier is the measure of efficiency. The output distance, D_O, is calculated using formula (1).

$$D_O(\mathbf{X},\mathbf{W}) = \inf_{\theta}\{\theta : (\mathbf{W}/\theta) \in \mathbf{P}(\mathbf{X})\} \qquad (1)$$

The closer to the frontier, the better the performance, and therefore the efficiency score is greater $(0 \leq \theta \leq 1)$. In other words, if production had been performed in an efficient way, the production of all welfare components would have been proportionally higher, by the factor $(1-\theta)/\theta$.

FIGURE A1.2

Illustration of output distance (Source: Färe and Grosskopf, 1996, page 49)

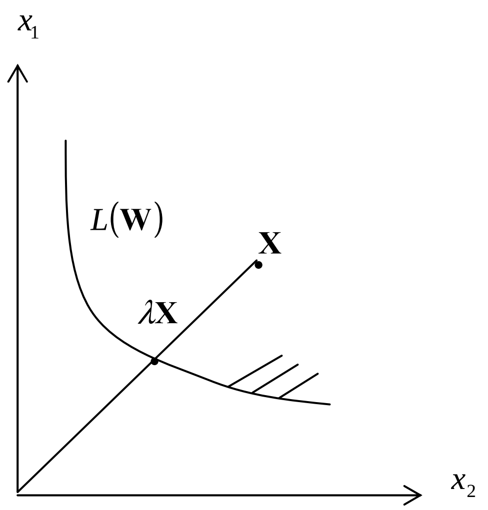


Input efficiency scores, defined by formula (2), supplement the output efficiency scores. The input efficiency measure, D_I, measures the minimum amount of resources (identified by the input set, $L(\mathbf{W})$) that would produce the given level of welfare as a share of the resources actually used.

$$D_I(\mathbf{W},\mathbf{X}) = \inf_{\lambda}\{\lambda : (\lambda\mathbf{X}) \in \mathbf{L}(\mathbf{W})\} \qquad (2)$$

FIGURE A1.3

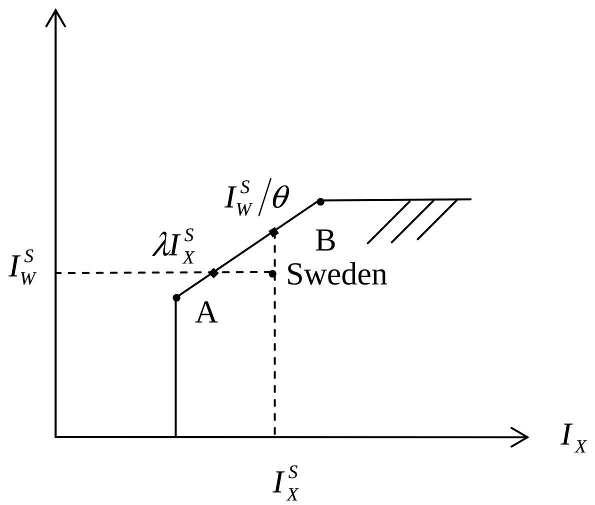
Illustration of input distance (Source: Färe and Grosskopf, 1994, page 65)



In this study one output index measuring welfare, I_W, and one input index, I_X, are used to estimate the efficiency of the production of welfare. This situation is shown by the graph in Figure A1.4. Assume that Sweden uses I_X^S to produce the welfare level I_W^S. The output efficiency and input efficiency are measured as the deviation from the best practice graph.

FIGURE A1.4

The graph (Source: Färe and Grosskopf, 1996, page 66)



Appendix 2 Welfare and input data and indices

The data are transformed into indices, ranging from zero to one. The UN applies the same calculation principle (UNDP, 2002). One example is the GDP per capita index, I_Y, calculated as $(Y - \min\{Y\})/(\max\{Y\} - \min\{Y\})$. The maximum and minimum GDPs per capita are \$35,724 and \$6,825. The Swedish GDP per capita is \$24,309. The Swedish GDP per capita index is $(24{,}309 - 6{,}825)/(35{,}724 - 6{,}825) \approx 0.605$. Input indices are calculated in the same way. One example is the labor index, I_L, calculated as $(L - \min\{L\})/(\max\{L\} - \min\{L\})$. Note that pollution is a negative (thing) and the pollution index, I_Z, is calculated as $(\max\{Z\} - Z)/(\max\{Z\} - \min\{Z\})$.

TABLE A2.1:
Welfare data (2000)

Country	Y (GDP)	M (Male life)	F (Female life)	Z (Emissions)
Canada	28,468	75.8	81.4	16
Mexico	9,164	72.4	77	3.7
US	35,724	73.9	79.4	9
Australia	26,800	75.9	81.5	17
Japan	26,484	77.2	84	9.1
Korea	17,636	70.6	78.1	8.8
New Zealand	19,808	75.2	80.4	8
Austria	25,788	74.7	80.9	7.5
Belgium	26,570	74.8	81.1	11.6
Czech Republic	14,262	71.1	78.1	10.8
Denmark	28,448	73.7	78.6	10
Finland	24,414	73.5	80.8	11.2
France	23,276	74.6	82.2	6
Germany	24,931	74.5	80.5	10
Greece	16,244	74.6	79.4	7.7
Hungary	12,251	66.1	75.2	5.8
Iceland	27,608	77	81.5	7.5
Ireland	28,895	73.2	78.5	10.7
Italy	24,395	75.3	81.6	7.3
Netherlands	27,662	75.2	80.7	10.5
Norway	29,311	75.5	81.3	8.3
Poland	9,184	68.9	77.3	8
Portugal	17,556	71.7	78.8	6.1
Spain	19,194	74.8	82.2	6.9
Sweden	24,309	76.9	81.9	5.4
Switzerland	29,892	76.5	82.5	5.6
Turkey	6,825	66.4	71	2.8
UK	22,882	74.6	79.7	9

TABLE A2.2
Input data (2000)

Country	L (Labor)	H (Education)	R (R&D)	I (Internet)
Canada	68.2	80	449.79	127.22
Mexico	60.3	20	31.16	3.82
US	65.9	87	946.69	234.2
Australia	67.1	57	399.32	74.99
Japan	68.5	81	482.01	32.49
Korea	71.4	66	449.72	10.76
New Zealand	65.3	74	223.83	92.6
Austria	67.5	74	469.34	57.55
Belgium	65.8	57	488.89	39.65
Czech Republic	69.1	86	181.13	12.89
Denmark	66.8	80	566.12	72.48
Finland	66.9	72	754.39	159.06
France	65.2	62	505.09	19.19
Germany	67.8	81	593.36	31.67
Greece	67.6	50	82.84	13.01
Hungary	68.2	67	83.31	15.38
Iceland	64.9	63	519.03	130.76
Ireland	66.6	51	401.64	31.13
Italy	68	43	253.71	32.61
Netherlands	68.2	65	539.41	81.62
Norway	64.7	85	507.08	116.47
Poland	68.1	78	68.88	8.25
Portugal	67.9	21	108.85	13.36
Spain	68.2	35	172.75	15.74
Sweden	64.2	77	899.43	106.31
Switzerland	67.3	82	816.05	63.46
Turkey	64.5	22	33.44	3.28
UK	65.1	82	418.74	52.5

TABLE A2.3

Welfare indices (2000)

Country	I_Y (GDP)	I_M (Male life)	I_F (Female life)	I_Z (Emissions)
Canada	0.75	0.87	0.80	0.07
Mexico	0.08	0.57	0.46	0.94
US	1.00	0.70	0.65	0.56
Australia	0.69	0.88	0.81	0.00
Japan	0.68	1.00	1.00	0.56
Korea	0.37	0.41	0.55	0.58
New Zealand	0.45	0.82	0.72	0.63
Austria	0.66	0.77	0.76	0.67
Belgium	0.68	0.78	0.78	0.38
Czech Republic	0.26	0.45	0.55	0.44
Denmark	0.75	0.68	0.58	0.49
Finland	0.61	0.67	0.75	0.41
France	0.57	0.77	0.86	0.77
Germany	0.63	0.76	0.73	0.49
Greece	0.33	0.77	0.65	0.65
Hungary	0.19	0.00	0.32	0.79
Iceland	0.72	0.98	0.81	0.67
Ireland	0.76	0.64	0.58	0.44
Italy	0.61	0.83	0.82	0.68
Netherlands	0.72	0.82	0.75	0.46
Norway	0.78	0.85	0.79	0.61
Poland	0.08	0.25	0.48	0.63
Portugal	0.37	0.50	0.60	0.77
Spain	0.43	0.78	0.86	0.71
Sweden	0.61	0.97	0.84	0.82
Switzerland	0.80	0.94	0.88	0.80
Turkey	0.00	0.03	0.00	1.00
UK	0.56	0.77	0.67	0.56

TABLE A2.4

Input indices (2000)

Country	I_L (Labor)	I_H (Education)	I_R (R&D)	I_I (Internet)
Canada	0.71	0.90	0.46	0.54
Mexico	0.00	0.00	0.00	0.00
US	0.50	1.00	1.00	1.00
Australia	0.61	0.55	0.40	0.31
Japan	0.74	0.91	0.49	0.13
Korea	1.00	0.69	0.46	0.03
New Zealand	0.45	0.81	0.21	0.39
Austria	0.65	0.81	0.48	0.24
Belgium	0.50	0.55	0.50	0.16
Czech Republic	0.79	0.99	0.16	0.04
Denmark	0.59	0.90	0.58	0.30
Finland	0.59	0.78	0.79	0.67
France	0.44	0.63	0.52	0.07
Germany	0.68	0.91	0.61	0.12
Greece	0.66	0.45	0.06	0.04
Hungary	0.71	0.70	0.06	0.05
Iceland	0.41	0.64	0.53	0.55
Ireland	0.57	0.46	0.40	0.12
Italy	0.69	0.34	0.24	0.13
Netherlands	0.71	0.67	0.56	0.34
Norway	0.40	0.97	0.52	0.49
Poland	0.70	0.87	0.04	0.02
Portugal	0.68	0.01	0.08	0.04
Spain	0.71	0.22	0.15	0.05
Sweden	0.35	0.85	0.95	0.45
Switzerland	0.63	0.93	0.86	0.26
Turkey	0.38	0.03	0.00	0.00
UK	0.43	0.93	0.42	0.21

Appendix 3 Transformation of estimated efficiency parameters

The estimated efficiency parameters are expressed in index terms (Appendix 1.3), and have to be transformed to be expressed in relation to the level of the variables. The current aggregate input index is expressed in equation (3), where $\mathbf{S_X} = (I, H, L, R)$. The weight attached to an input variable, i, is α_i. In the text, (normal) averages are used, i.e. $\alpha = \alpha_i \; \forall \, \mathrm{i}$. In Appendices 4 and 5, weighted averages are applied.

$$I_X = \left(\sum_{i \in \mathbf{S_X}} \alpha_i \left(i - \min\{i\}\right) / \left(\max\{i\} - \min\{i\}\right) \right) \Big/ \sum_{i \in \mathbf{S_X}} \alpha_i \qquad (3)$$

In an efficient situation this index should be reduced to λI_X (Appendix 1.3). In levels this efficient input index corresponds to λ^*, so that λI_X equals $\left(\sum_{i \in \mathbf{S_X}} \alpha_i \left(\lambda^* i - \min\{i\}\right) / \left(\max\{i\} - \min\{i\}\right) \right) \Big/ \sum_{i \in \mathbf{S_X}} \alpha_i$. Observe that $\lambda^* > \lambda$.

The current welfare index is expressed in equation (4), where $\mathbf{S_G} = (Y, M, F)$ and $\mathbf{S_W} = (Y, M, F, Z)$. The weight attached to a welfare component, i, is β_i. In the text, (normal) averages are used, i.e. $\beta = \beta_i \; \forall \, \mathrm{i}$. In Appendices 4 and 5, weighted averages are applied. Observe that pollution, Z, is negative, and this is the reason for the special treatment of this variable.

$$I_W = \left(\beta_Z \left(\max\{Z\} - Z\right) / \left(\max\{Z\} - \min\{Z\}\right) + \sum_{i \in \mathbf{S_G}} \beta_i \left(i - \min\{i\}\right) / \left(\max\{i\} - \min\{i\}\right) \right) \Big/ \sum_{i \in \mathbf{S_W}} \beta_i \qquad (4)$$

The transformation consists of finding θ^* so that $(1/\theta) I_W$ equals $\left(\beta_Z \left(\max\{Z\} - \theta^* Z\right) / \left(\max\{Z\} - \min\{Z\}\right) + \sum_{i \in \mathbf{S_G}} \beta_i \left((1/\theta^*) i - \min\{i\}\right) / \left(\max\{i\} - \min\{i\}\right) \right) \Big/ \sum_{i \in \mathbf{S_W}} \beta_i$.

Note that $\theta^* > \theta$.

The interpretation of these transformed indices differs between positive and negative variables. Positive welfare components could be increased by a factor $\left(1 - \theta^*\right)/\theta^*$. Negative welfare components could be reduced by a factor $1 - \theta^*$. In other words, increasing positive variables by a factor $\left(1 - \theta^*\right)/\theta^*$ corresponds to reducing negative variables by a factor $1 - \theta^*$. However, only $\left(1 - \theta^*\right)/\theta^*$ are presented in tables in the text.

Appendix 4 DEA using factor analysis

In the text welfare components and inputs were aggregated using (normal) averages. In this section, welfare components and inputs are aggregated using weighted averages. The weighting procedure is based on factor analysis (Appendix A1.2). In Appendix 5, an alternative weighting procedure is presented, leading to entropy-like aggregate measures of welfare components and inputs.

Factor analysis is used for both input variables and output variables. The analysis of the output indices is, in essence, a construction of a welfare index by calculating a weighted average of the included variables, $W = \mathbf{W}'\boldsymbol{\beta}$, where $\boldsymbol{\beta}$ is the estimated weight vector (Table A4.1). As in Nicoletti, Scarpetta and Boylaud (2000), the (normalised) squared loadings are used as weights. Moreover, this level of welfare is related to the maximum welfare obtained by a country, in the aggregate welfare index $I_W(Y, M, F, Z)$, which is presented in Table A4.2. Inputs to production are grouped into an aggregated measure of all inputs, $X = \mathbf{X}'\boldsymbol{\alpha}$, where $\boldsymbol{\alpha}$ is the estimated weight vector (Table A4.1). The estimated aggregate measure of inputs is related to the maximum value, creating an aggregate input index, $I_X(L, H, R, I)$, which is presented in Table A4.2. In Table A4.1 it can be seen that, by applying this weighting procedure, higher education plays no role in the aggregate input index, and the negative welfare effects of pollution are reduced.

In Sweden, the aggregate input index amounts to 54 per cent. The aggregate welfare index in Sweden amounts to 94 per cent. Turkey, Mexico, Spain, Japan, and Switzerland are efficient. Switzerland is the Swedish benchmark. Efficient production of welfare would increase the welfare index by seven per cent (Table A4.3). Alternatively, the same welfare index could be accomplished by 30 per cent of the input index. Note that the efficiency estimates could be transformed into levels using the procedure described in Appendix 3.

FIGURE A4.1

The best practice graph relating the weighted input index, $I_X(L,H,R,I)$, and the weighted welfare index, $I_W(Y,M,F,Z)$, based on the variable returns to scale assumption

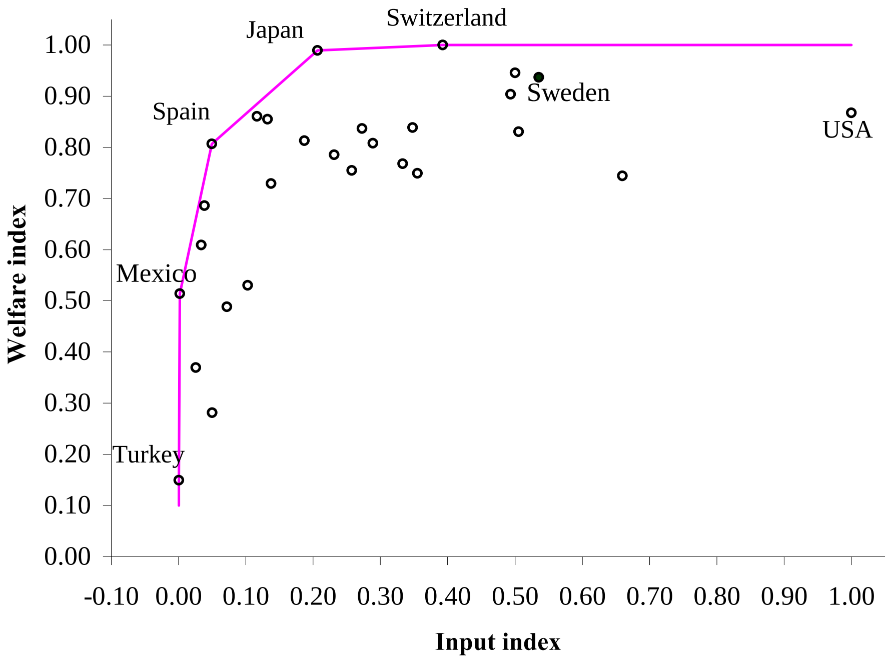


TABLE A4.1

The input and welfare weights

Variable	α	Variable	β
L	0.33	Y	0.28
H	0.00	M	0.30
R	0.29	F	0.30
I	0.37	Z	0.12

TABLE A4.2

Welfare and input indices year 2000

Country	$I_X(L,H,R,I)$ **(%)**	**Country**	$I_W(Y,M,F,Z)$ **(%)**
US	100	Switzerland	100
Finland	66	Japan	99
Sweden	54	Iceland	95
Canada	51	Sweden	94
Iceland	50	Norway	90
Norway	49	US	87
Switzerland	39	Italy	86
Denmark	36	France	85
Netherlands	35	Netherlands	84
New Zealand	33	Austria	84
Australia	29	Canada	83
Austria	27	Belgium	81
UK	26	Australia	81
Germany	23	Spain	81
Japan	21	Germany	79
Belgium	19	New Zealand	77
Ireland	14	UK	75
France	13	Denmark	75
Italy	12	Finland	74
Korea	10	Ireland	73
Czech Republic	7	Greece	69
Hungary	5	Portugal	61
Spain	5	Korea	53
Greece	4	Mexico	51
Portugal	3	Czech Republic	49
Poland	3	Poland	37
Mexico	0	Hungary	28
Turkey	0	Turkey	15

TABLE A4.3

The output and input efficiency scores for the year 2000, based on the weighted average welfare and input indices

Country	$(1-\theta)/\theta$ **(%)**	**Country**	λ
Japan	0	Japan	1.00
Mexico	0	Mexico	1.00
Spain	0	Spain	1.00
Switzerland	0	Switzerland	1.00
Turkey	0	Turkey	1.00
Italy	3	Italy	0.82
France	6	Greece	0.78
Iceland	6	France	0.69
Sweden	7	Portugal	0.51
Greece	8	Iceland	0.34
Norway	11	Sweden	0.30
US	15	Belgium	0.30
Portugal	16	Austria	0.28
Austria	19	Norway	0.27
Belgium	19	Ireland	0.27
Netherlands	19	Netherlands	0.22
Canada	20	Germany	0.20
Australia	23	Australia	0.17
Ireland	25	UK	0.16
Germany	26	Canada	0.14
New Zealand	30	New Zealand	0.13
UK	31	Denmark	0.11
Denmark	33	US	0.10
Finland	34	Finland	0.06
Korea	64	Poland	0.05
Czech Republic	70	Korea	0.04
Poland	78	Czech Republic	0.02
Hungary	187	Hungary	0.02

Appendix 5 DEA using entropy-like measures of welfare and input

In the text aggregate measures of welfare components and inputs are calculated by forming averages. In Appendix 4, welfare components and inputs were aggregated using weights estimated by factor analysis. In this section an alternative weighting procedure is applied. Here an index value is given a weight equal to the natural logarithm of the index value, producing two entropy-like measures of welfare and input, $W = \sum_{i \in \mathbf{S_W}} I_i \ln I_i$ and $X = \sum_{i \in \mathbf{S_X}} I_i \ln I_i$, respectively.By weighting in this way, the weight applied to expected length of life in Sweden is higher than the corresponding weight for the US. The reverse applies for the economic situation, i.e. GDP per capita. In other words, the welfare function differs between countries. As before, the aggregate welfare and input measures are related to the maximum value attained by any country, in two welfare and input indices, I_W and I_X, respectively (Table A5.1). Portugal, Spain, Italy, Iceland, Japan, and Switzerland are efficient (Figure A5.1). Japan and Switzerland are the Swedish benchmark countries. The welfare index in Sweden would be six per cent higher with efficient resource use (Table A5.2). Turkey, Mexico, Hungary and Australia have been removed, due to problems concerning transformation of data. Note that efficiency estimates could be transformed into levels using the procedure described in Appendix 3.

TABLE A5.1

Welfare and input indices year 2000

Country	$I_X(L,H,R,I)$ **(%)**	**Country**	$I_W(Y,M,F,Z)$ **(%)**
US	100	Switzerland	100
Finland	77	Japan	94
Switzerland	73	Sweden	94
Sweden	70	Iceland	91
Canada	69	Norway	86
Norway	62	France	84
Denmark	62	Italy	83
Germany	62	US	82
Japan	60	Austria	80
Korea	59	Spain	78
Netherlands	59	Netherlands	77
Austria	56	Belgium	73
Iceland	54	New Zealand	73
Czech Republic	54	Germany	72
UK	51	Canada	71
New Zealand	46	UK	70
Poland	44	Denmark	68
Belgium	41	Finland	66
France	41	Ireland	66
Ireland	37	Greece	65
Italy	33	Portugal	60
Greece	29	Korea	48
Spain	27	Czech Republic	42
Portugal	20	Poland	36

FIGURE A5.1

The best practice graph relating the weighted input index, $I_X(L,H,R,I)$, and the weighted welfare index, $I_W(Y,M,F,Z)$, based on the variable returns to scale assumption

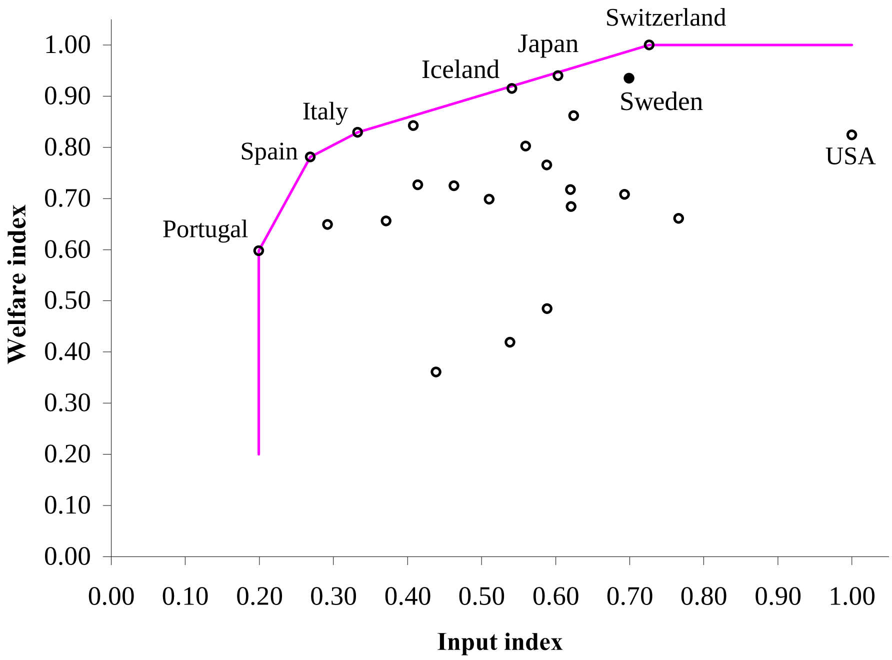


TABLE A5.2

The output and input efficiency scores for the year 2000, based on the weighted average welfare and input indices

Country	$(1-\theta)/\theta$ **(%)**	**Country**	λ
Iceland	0	Iceland	1.00
Italy	0	Italy	1.00
Japan	0	Japan	1.00
Portugal	0	Portugal	1.00
Spain	0	Spain	1.00
Switzerland	0	Switzerland	1.00
France	2	France	0.89
Sweden	6	Sweden	0.85
Norway	10	Greece	0.75
Austria	15	Norway	0.66
Belgium	19	Belgium	0.60
US	21	Ireland	0.60
New Zealand	22	New Zealand	0.54
Netherlands	22	Austria	0.53
Greece	23	UK	0.47
Ireland	29	Poland	0.45
UK	29	Netherlands	0.45
Germany	32	Germany	0.39
Denmark	39	Denmark	0.37
Canada	39	Czech Republic	0.37
Finland	51	Canada	0.35
Korea	93	Korea	0.34
Czech Republic	118	US	0.33
Poland	142	Finland	0.29

ITPS, Institutet för tillväxtpolitiska studier
Studentplan 3, 831 40 Östersund
Telefon: 063 16 66 00
Fax: 063 16 66 01
info@itps.se
www.itps.se
ISSN 1652-0483

INSTITUTET FÖR TILLVÄXTPOLITISKA STUDIER