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PILOT INDICES OF GENUINE SAVINGS FOR THE UK AND TAIWAN, FROM 1970 TO 1998

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Abstract

Genuine Savings Index (GSI) is a simple indicator to assess an economy's sustainability. It defines wealth more broadly than orthodox national accounts, and recalculates national savings figures based on this new definition. Genuine Savings (GS) aim to represent the value of the net change in the whole range of assets that are important for development: produced assets, natural resources, environmental quality, and human resources.

This paper takes the broad framework developed earlier and tests its application to two countries, The UK and Taiwan, between the years 1970 and 1998 with the goal of assessing the feasibility of using such measures quite broadly as indices of sustainable development (SD). It shows both the UK and Taiwan have positive GS rates over the years, but the UK has relatively lower ones. Sources of data and methodological factors are discussed, national comparability is investigated, and the policy uses derived from the exercise are analyzed.

Key Words: Genuine Savings; National Capital; Sustainable Development; Economic Growth; GDP; National Accounting; Environmental Pollution; Natural Resource Depletion.

Introduction

The concept of GS is based on a measure of wealth that is expanded to include human and natural, as well as economic, wealth. It measures the net annual increase or decrease in a nation's wealth. According to previous definitions, development is considered to be sustainable if and only if the stock of capital (wealth) remains constant or rises over time. Thus, the rate of GS can be used to measure sustainability, in that if genuine savings is positive, we are leaving more for future generations; a negative rate of GS indicates unsustainability.

Constant Capital Rule

The starting point of the Genuine Savings concept is just compatible to the mainstream definition of Sustainable Development. SD is defined as some measure of per capita human well-being which does not decline over time (Pearce *et al.* 1989). And in the end, the GS could be seen as a straightforward SD indicator.

The concept of the GSI is based on the '*constant (unchanged) capital rule*'; the rationale of its measuring sustainability is also through its measurement of 'changes in wealth' (wealth is the sum of all the capitals, including man-made, natural, and human capitals). The purpose of the indicator is therefore to offer an indication of whether a nation's economy is sustainable or not, through assessing the changes in a nation's wealth: if the savings of the wealth (all capitals) are not enough (the GSI is consistently negative) for the future, then the economy of a nation is not sustainable.

For future generations to be better off than we are today, they must have the *capacity* to generate more well-being than we have. Indeed, as there are going to be many more people in the future, that increase in capacity must be quite marked if per capita well-being is to improve. But on what does well-being depend? It depends on the capability for self-realization and fulfilment and we know that this depends heavily on education, skills and knowledge. This is *human capital.*

We know that the capacity to generate high per capita output of goods and services, upon which well-being undeniably depends, is determined by the availability of human capital and also stocks of machinery and infrastructure, or *man-made capital.*

Then, we have now come to recognize that the stock of environmental assets, or *natural capital,* is important for well-being, not just because they create amenity and beauty, but because they affect our physical and mental health as well.

Finally we have social capital. Social capital refers to a social and cultural degree that makes a society more than the sum of a collection of individuals. The most narrow concept of social capital is associated with Putman (Putman, 1993). He views it as a set of 'horizontal associations' between people: social capital consists of social networks and associated norms that have an effect on the productivity of the community. In short, if that social capital is not there, the resulting failures make it difficult to talk of economic growth, environmental sustainability or human wellbeing. We may think that social capital is from inclusion, participation/promotion of an active environment. Yet it is more. The most ambitious work to date on this subject has been the endeavour to deal with the link between good governance and development. However, this requires further definition and measurement efforts.

Capital provides the capability to generate well-being through the creation of the goods and services upon which human well-being depends (Pearce *et al*, 1989, 1990). So, the future capacity to sustain development depends on these stock of capital, and this gives us the clue to getting sustainable development.

As a general rule, these stock of capital should not decline through time: we should pass on to the next generation at least as much capital as we have today. More precisely, per capita stocks should not decline through time, a rule that has come to be known as the *constant capital rule*.[1] There is one way that we can modify this statement. An existing stock of capital can do more 'work'. i.e., provide more well-being, if it embodies the latest technology. So, our constant capital rule could be restated as keeping a technology-weighted per capita index of total capital at least constant through time. Yet another way of thinking about it to say that total capital stocks should be constant or rising, and that technological change should grow at least as fast, and preferably faster, than population change. This formulation comes very close to the way economists formulated sustainable economic growth requirements in the 1970s (e.g., Stiglitz, 1979)

Therefore, sustainable development is about ensuring that human well-being generated from the capital is sustained over time. The literature on sustainable development is generally

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[1] For extensive discussion and analysis of this rule see Atkinson *et al* (1997).

agreed that the mechanism whereby current generations can compensate the future is through the transfer of capital bequests. What this means is that this generation makes sure that it leaves the next generation a stock of capital no less than this generation has now. The welfare significance of GS is that persistent negative GS rates must lead to nonsustainability, in the sense that the level of welfare of the country will eventually decline

Genuine Savings

The calculation of GS involves the itemization of a nation's stock of wealth, and an accounting of changes to that stock. The World Bank researchers have defined GS as follows:

= Production - Consumption - Depreciation of Produced Assets - Depletion of Natural Assets

= Gross Domestic Savings – Consumption of Fixed Capital (Depreciation) + Education Expenditure – Air Pollution Costs – Water Pollution Costs – Depletion of Nonrenewable Natural Resources – CO2 Damage Costs [2]

Table 1 presents a summary of the composition of the GSI with the main rationale for each of the adjustments made.

Preliminary calculations from the World Bank suggest that this measure of GS tends to depress the savings rates of resource-rich developing countries, meaning that current patterns of economic activity are diminishing national wealth. Similarly, depressed rates of GS for resource-rich countries represent opportunities -- resources are being depleted, rather than transformed into assets.

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[2] This also equals "Gross Domestic Investment + Education Expenditure + Current Account Balance After Official Transfers – Consumption of Fixed Capital (Depreciation) – Air Pollution Costs – Water Pollution Costs – Depletion of Nonrenewable Natural Resources – CO2 Damage Costs"

Table 1. Summary of the GS Calculation Methodology

Item	Adjustment	Rationale
Gross domestic savings		Basis for the index
Consumption of fixed capital	-	Accounting for replacement value of produced capital in the production process
Education expenditure	+	Adding in value of investments in human capital
Air pollution costs	-	Subtracting the environmental degradation costs
Water pollution costs	-	Subtracting the environmental degradation costs
CO2 damage costs	-	Subtracting the environmental long-term damage costs
Natural resource depletion costs	-	Subtracting the declining costs of natural capital due to extraction or harvest
Genuine savings		Standing for how much a country truly saves for future

In this case study, we chose the UK and Taiwan, using the GS framework and testing its application to both countries between the years 1970 and 1998, with the aim of assessing the feasibility of using such a measure as an index of national sustainable development. The estimates reported in this paper were constructed independently of the Work Bank's 1997 estimates. Sources of data and methodological factors are discussed, comparability of the two countries is investigated, and the policy uses are analyzed.

Why the GSI a Better SD Measure than Others?

The GS framework offers a holistic approach and puts a major emphasis on the linkages among the main dimensions of SD: economic, natural, social, and human aspects. Extending the definition of capital to natural, human and social capital is an easily understood and powerful concept that could link sustainability and development, and provide whole-system approach. The concept of capital allows the stock-flow analysis that can make indices dynamic. It is *future oriented*, deals with trends due to the notion of capital.

The GSI offers a calculation method, expressing the indicators in comparable monetized terms, and makes aggregation easy. Also the methodology is based on the balance sheet calculations of national accounts, providing understanding for key economic policy makers.

The GSI also has a role in setting an economy's objectives and linking them to actions. Its policy uses and contributions are clear and obvious as just mentioned. So it is a performance indicator: a tool for comparison, incorporating a reference value for a policy target. It could provide decision makers with information on how they are doing with regard to relevant policy goals and objectives.

In contrast, some other similar work on sustainable development measurement can't be this theoretically efficient and persuasive. The physical indicator[3] is an example. Other aggregate indicators include the Index of Sustainable Economic Welfare (ISEW) and the Human Development Index (HDI). Other SD indices such as these physical indicators or social indicators might be short of two to three dimensions in their measurement of sustainable development.

Among these other SD measures, the ISEW might have tried to address more aspects of issues of sustainable development while devised as a SD measuring tool. Daly & Cobb (1989), and Cobb &Cobb (1994) expected a positive correlation between Hicksian income (the amount of income that people can spend for consumption goods without impoverishing themselves) and economic welfare.

Therefore, they developed an index called the 'Index for Sustainable Economic Welfare', to measure Hicksian income (1946) by subtracting the 'defensive expenditures' from conventional national income[4]. To compute national income they add the value of the services

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[3] The physical indicators of sustainable development are mainly concerned with the ecological respect. They consist of 'carrying capacity', 'ecological footprint', 'resilience', and so on.

[4] Trial compilations of the ISEW include ISEW-USA by Cobb and Cobb (1994), ISEW-UK by Marks and Jackson (1994) and New Economics Foundation, ISEW-Italy, ISEW-Germany, ISEW-Spain,

of household labour. Defensive expenditures in their methodology includes defensive private expenditures on health and education, costs of commuting, urbanization and auto accidents, costs of different sorts of pollution, depletion of non-renewable resources, long-term environmental damage, and so on.

Since data is not readily available in all these categories, they have to make many arbitrary assumptions to compute the defensive expenditures in monetary terms. This is the greatest critique that the ISEW has received.

Others criticize the limitations of Daly and Cobb's computational methodology with an example. Daly and Cobb assume that the welfare effects of living in urban areas are negative because of the higher cost of commuting, higher cost of housing and disutility from externalities. But they have completely ignored the 'positive externalities' of city life. If the positive externalities are large, Daly and Cobb's adjustments of national accounts may be in the wrong direction. Similar arguments can be made about rural-urban migration.

Even with the limitations of the ISEW, there has been a tendency of convergence among mainstream economists and international organizations toward the acceptance of theoretical ISEW. Because of its imperfections, the proponents of ISEW call for scholarly help from various fields to improve on their methodology (Cobb and Cobb, 1994).

The UK-GS and Taiwan-GS: Item by Item

In here, we will item by item, detail our calculations of the UK-GS and Taiwan-GS. We have some different methods with regard to calculating some components of the GS from the World Bank, where possible we will attempt in what follows to highlight the important methodology issues and discuss the significant effects on the overall shape of the GSI.

The compared target to this study is the World Bank's prior trial compilation of the GSI. The

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ISEW-Taiwan, and so on.

World Bank's global GSI was presented for the years 1974 to1994. For the UK-GS and Taiwan-GS that will be shown in the following sections, we have extended the survey period, which is from 1970 to 1998.

Item A: Gross Domestic Savings

The starting point for the GS is gross domestic savings. According to the standard national accounting, gross domestic savings are calculated as the difference between Gross Domestic Product (GDP) and public and private consumption. Gross domestic savings also equals gross domestic investment plus current account balance after official transfers in national accounting terms.

For the UK, this information is published regularly in the UK National Accounts and time series data is set out in detail in Economic Trends Annual Supplements, various years. So, the data of gross domestic savings were obtained from this source.

For Taiwan, this information can be obtained from the National Accounts publications as well. In this part, the data of Taiwan were derived from National Income Account, National Statistics of Taiwan, various years.

Item B: Consumption of Fixed Capital

Consumption of fixed capital represents the replacement value of capital used up in the process of production. Net domestic savings are equal to gross domestic savings less the value of consumption of fixed capital.

For the UK, the data were from the United Nations Statistics Division's Statistical Yearbook, various years.

For Taiwan, this information was derived from National Income Account, National Statistics of Taiwan, various years.

Item C: Education Expenditure

In national accounts, education expenditure refers to the current operating expenditures in education, including wages and salaries and excluding capital investments in buildings and equipment. In the GS model, current expenditures on education are added to net domestic savings as an approximate value of investments in human capital (in standard national accounting, these expenditures are treated as consumption).

For the UK, the data were from the Economic Trends, various years. For Taiwan, they were taken from the Ministry of Education, Taiwan, various years.

Item D: Air Pollution Costs

The World Bank's global GS calculation table doesn't include the item of air pollution costs. So, we carried out the exercise in valuing air pollution for the years in order to put these costs into our GS calculation.

For the UK, estimates of the marginal social costs per tonne emitted are used and are shown in Table1. Five key pollutants are included: particulates (black smoke), sulphur dioxide, nitrogen oxides, carbon monoxide, and volatile organic compounds. These five main pollutants are acknowledged and publicized by Department of Environment, Transport and Regions (DETR), the UK. We have then multiplied emissions of each pollutant by an estimate of the marginal social costs of that pollutant to obtain the costs of each kind of air pollution in each year. (The unit of damage cost will be the average of the Tellus cost and Pace cost.[5]) The total negative costs flowing from all the air pollutants in a given year are taken to be the yearly air pollution costs.

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[5] The Pace figures are essentially based on a review of the literature on damage costs. The Tellus figures are based on the control cost method of monetarisation. This exercise has used an average of the two costs.

The data of varied pollutant emissions for various years were derived from DETR, the UK.

Recently, considerable attention has been given to the task of allocating externality 'shadow costs' for use in determining appropriate levels of investment in and dispatch of energy technologies (Baumann and Hill 1991, Hohmeyer 1993, Pace 1990, Tellus 1991). A number of state utilities in the US have actually adopted some form of economic 'adder' or shadow cost for different pollutants when making planning decisions (Woolf 1992). Accordingly there have been a number of attempts to identify specific costs per tonne of emissions. Among those, Tellus and Pace's estimates are more often taken as references for the relevant studies. Their recent estimates are shown (in 1985 pounds) in Table 2 below.

Table 2. Marginal Costs of Air Pollutant Emissions--£/tonne

Tellus (1991)	
NOx	2836
SO2	655
Smoke	1745
VOCs	2312
CO	389
Pace (1990)	
NOx	715
SO2	1771
Smoke	1038
PM10	1044

After compilation, the result shows that the air pollution costs as a percentage of the GDP for the UK decreased each year. For details please see the next section of this study.

For Taiwan, they don't have direct estimates of the marginal social costs per tonne of air pollutant emitted, but have estimates of 'air pollution marginal social costs per unit of energy consumed'. We therefore calculated the air pollution costs per year as the sum of air pollution marginal social costs associated with a unit of energy consumed multiplied by the energy consumption for that year. Table 3 shows the estimate of air pollution marginal social costs per unit of energy consumed.

Table 3. Taiwan's Air Pollution Social Costs of Energy Consumed --NT$/Liter (1991)

Energy	Social Costs
Fuel Oil	8.58
Motor Gasoline	0.61
Diesel Oil	2.88
LPG	0.17
Natural Gas	0.10
Coal	7.79

Source: Liang, Chi-Yuan (1993), "The Effect of the Environmental Protection Policy on the Economy of Taiwan." Far Eastern Meeting of the Econometric Society, Taipei, Taiwan.

The energy consumption data were obtained from the Taiwan Energy Commissions, various years.

Item E: Water Pollution Costs

The World Bank's global GS Table also doesn't have this item included. So, we tried to allocate the data and estimated this sort of cost by ourselves.

Up to now, the methods of evaluating costs of water pollution in many countries have still been uncertain. Some of the suggesting methods are fairly arbitrary. For instance, with the ISEW methodology, to have an estimate of water pollution costs needs to estimate the changes in the impacts of water pollution over the periods counted. Therefore, the national river quality surveys need to be done through various years. Creating a water quality index would be the starting point. However, creating the index of water quality is complicated and lacks classification standards and no such surveys have been done for either the UK or Taiwan presently.

We also were unable to find any other cost estimates for water pollution in the UK and Taiwan. The OECD has estimated public expenditures on water pollution in various years (OECD 1991, p59). In the middle-seventies, for instance, public expenditure on water pollution in the UK was reckoned at around $40 per capita at 1980 prices.

So, we mainly followed this method and found out the two nations' government and industrial defensive expenditures on water pollution over the years covered. The total defensive expenditures for each year are taken as annual water pollution costs.

This information for the UK was taken from the UK National Statistics, various years. For Taiwan, the data were derived from National Statistics of Taiwan, various years.

Item F: CO2 Damage Costs

In the World Bank's global GS calculation, the CO2 item is essential, but the data collected from them are not completed, and are missing for several countries. They don't have the data for Taiwan, for instance.

Besides, the World Bank's estimations of CO2 damage costs over the years are not straightforward. They think that the contribution to CO2 damages for each year should be the product of total annual carbon emissions and an estimate of marginal social cost per unit emitted. However, they contend that the associated costs are accumulated through the time.

Similar to the method of evaluating air pollution costs, our way of estimating CO2 damages is to calculate the cost itself for each year, but not through accumulation. We view this way as a more straightforward calculation. For this, we needed the estimation of CO2 marginal social cost per unit and the total annual carbon emission. For each year, the CO2 damage cost is therefore the two numbers multiplied to each other.

For the UK-GS, the data on annual carbon emissions were from the UK National Air Quality Information Archive. And the estimation of marginal social cost was taken from PAGE 95 [6] (= 21, in 1990 $/ tC).

For the Taiwan-GS, the data on annual carbon emissions were from the Environmental Protection Agency (EPA), and the estimation of marginal social cost was taken from Wei and Lee (=17, in 1990 $/ tC).

Item G: Nonrenewable Resource Depletion Costs

For the "nonrenewable natural resources depletion" evaluation, the user cost method [7], compared to other ways, is theoretically better, but not practically feasible, especially applied to the empirical calculation. The main reason is about the calculation of n, the number of years to exhaustion of a resource, which poses some conceptual problems. The longevity of a mineral/natural resource deposit at a specified rate of extraction is not a simple physical fact. The availability of the resource is a function not only of how much is ‘out there’ but also of the intensity of the effort (in labour, capital, and energy) used to extract it. In other words, in El Serafy's equation, n is dependent on an exogenous variable, extraction costs, which are nearly impossible to be defined and measured practically.

Another ISEW's method for estimating this nonrenewable resource depletion-- setting certain

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[6] The PAGE (Policy Analysis for the Greenhouse Effect) integrated assessment model was developed in 1991 for use by European Union decision makers (Hope *et al*, 1993). An updated model version, PAGE 95, accounts for recent developments in the science and economics of global warming (Plambeck *et al*, 1995).

[7] The basic idea of the 'user- cost valuation' is to convert a time-bound stream of (net) receipts R from the sales of an exhaustible resource into a permanent income stream X by investing a part of the receipts, i.e. the user-cost allowance R-X over the life time of the resource. Only the remaining amount X of the receipts should be considered 'true income'. It can be shown (El Serafy, 1989) that the user-cost allowance at the interest rate r and the lifetime of the resource of n years amounts to:
$R\text{-}X = R / (1+r)^{n+1}$

replacement costs reflecting the costs of replacing each barrel of oil equivalent of energy consumed with renewable resource, is also arbitrary and lacks related justifying theories.

Therefore, we followed the method that had been used by the World Bank for estimating the resource depletion cost -- the "rental depletion" method, which is theoretically and practically acceptable under such a circumstance. The Unit Resource Rent = Market Price – Cost of Extraction. In this study, for both the UK and Taiwan, the resources refer to coal, natural gas, and oil.

For the UK-GS, the natural resource depletion costs data were from the World Bank working paper ‘Estimating National Wealth’ (Kunte and others, 1998) and the World Bank ‘World Development Indicators’.

For the Taiwan-GS, the data were from the World Bank working paper ‘Estimating National Wealth’ (Kunte and others, 1998) and the World Bank ‘World Development Indicators’, and Taiwan Green Accounting Trial Compilation, 1999.

Results and Discussion: Taiwan-GS and UK-GS

GDP versus GS

National economic performance is commonly measured through the indicator known as the Gross Domestic Product (GDP). According to conventional wisdom, rising GDP is good. Although the use of GDP as an indicator of economic success has a strong political power, for example, when GDP falls, businesses go bust, jobs get lost, homes are repossessed, consumer spending falls, personal savings are reduced, public sector borrowing and trade deficits rise, and so on. It is also now well-known that the path of national economic success is not the same as that of national sustainable development. That’s why we choose the GSI as a more proper indicator of national sustainable development -- whether a nation saves enough in terms of its multiplied capital for the future to sustain its social and economic development or achievements.

Now, through our compilation of the Taiwan-GS, the results are shown in Table 4 with regard to the average GDP growth rates and average GS ratios to the GDP during the years from 1970 to 1998. Figure 1 then presents the changes in the amounts of Taiwan's GDP and GS over those years.

Figure 1. GDP vs. GS, Taiwan, 1970-1998

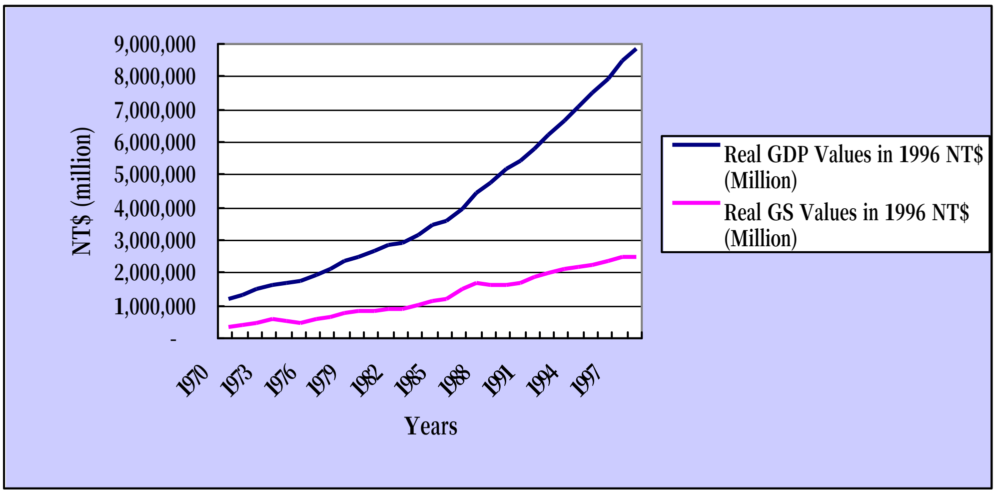


Table 4. Average Real GDP Growth Rates and Average GS Ratios to the GDP, Taiwan

	1970s	1980s	1990s
Average Annual Growth Rates of Real GDP	10%	8%	6%
Average Annual Ratios of the GS to the GDP	17.5%	27.8%	27.7%

As stated above, GDP rates account for a country's pure economic performance. During the 1970s, Taiwan's average economic growth was a bit faster than 1980s and 1990s (the average annual GDP growth rate was higher during the period of 1970s), due to the national economic development policy. In the process of economic development, whether a country is going towards a sustainable path, can be judged by its GS rates. If the GS rates are negative, then this is a serious warning as to its unsustainability.

Through our investigation and calculation of the Taiwan-GS, during the past thirty years, the yearly Taiwan-GS was positive. This means that when associated with its economic activities, the country's overall capital wealth can still be sustained for the future use and development. Moreover, from Table 4 we can see that the average GS ratios to the GDP were higher in the 1980s and 1990s than in the 1970s. That's probably because of the government's environmental policy performance especially in pollution controls, as well as a slow-down economic growth in the years of 1980s and 1990s – with less economic activities, the national capital wouldn't be used (depleted) so much, and the pollution caused by the activities wouldn't be so bad, either.

We also have the results as shown in Table 5 displaying the UK's average annual GDP growth rates and average annual GS ratios to the GDP over the years 1970 to 1998. Figure 2 then presents the changes in the value of the UK's GDP and GS over those years.

Table 5. Average Real GDP Growth Rates and Average GS Ratios, the UK

	1970s	1980s	1990s
Average Annual Growth Rates of Real GDP	2 %	3%	2%
Average Annual Ratios of the GS to the GDP	8.8 %	5.6%	6.8%

From Table 5, we see that, as a developed country, the UK had lower average annual GDP growth rates than Taiwan, in the periods of 1970s, 1980s, and 1990s. Besides, along with economic activities, the UK also had a bit lower average GS ratios to the GDP than Taiwan over the years.

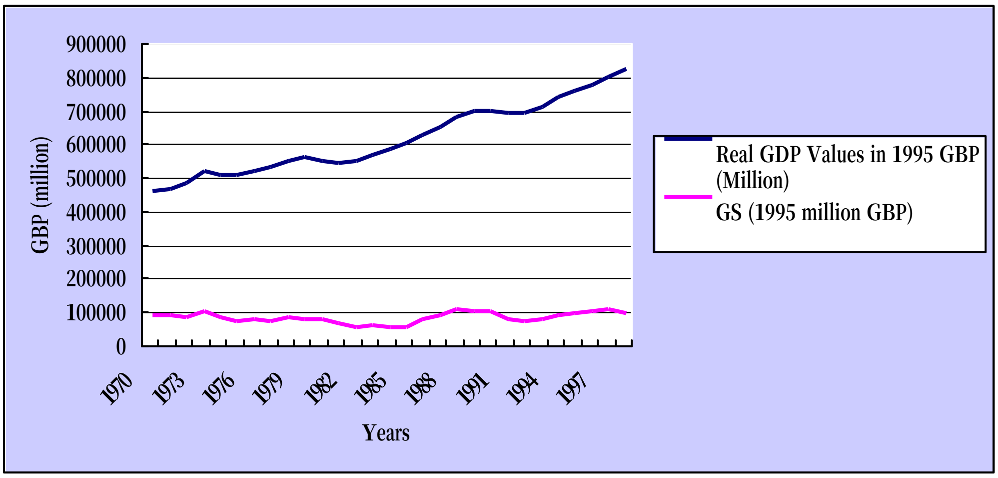
From the 1970s to 1980s, the average annual UK-GDP growth rate lifted slightly (from 2.4% to 2.9%), which means the economic development as well as economic growth was boosted.

However, the average annual UK-GS ratio to the UK-GDP went down (from 8.8% to 5.6%) during the same course. As noted before, it's because that high degree of economic development has most likely led to more natural resource depletion and greater environmental degradation, which then renders a lower GS rate.

From 1980s to 1990s, however, the average annual UK-GDP growth rate grew lower (from 2.9% to 2.1%), and the average annual UK-GS ratio to the UK-GDP went higher (from 5.6% to 6.8%). Likewise, when the economic activities are not proceeding very aggressively, depletion and pollution could be lessened, and the GS rates could be heightened.

In sum, during the past 30 years, the UK-GS were also all positive, which means that in the first place, the country didn't move toward an unsustainable path when using its man-made, natural, and human capital to promote the current economic development.

Figure 2. GDP vs. GS, the UK, 1970-1998



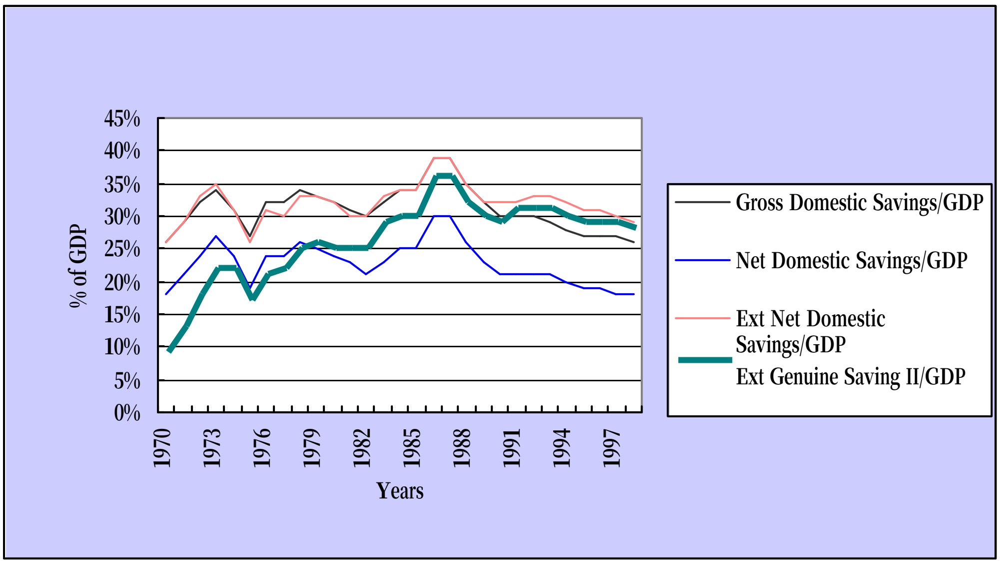
Components of Genuine Savings

The traditional measure of a nation's rate of accumulation of wealth, as reported in the World Bank's 'World Development Indicators', is Gross Savings. This is calculated as a residual:

GNP minus public and private consumption. Net Savings, total gross savings less the value of depreciation of produced assets, is a first step towards a sustainability indicator. Measures of GS address a much broader conception of sustainability, by valuing changes in the natural resource base and environmental quality in addition to produced assets.

Figure 3 presents the components of the Taiwan-GS as shares of GDP. The starting point in the calculation of GS is standard accounting. The top curve in Figure 3 is *Gross Domestic Savings* of Taiwan. Next, the depreciation of produced assets is subtracted from the top curve to give *Net Domestic Savings*. Next, the education expenditures are added, yielding the curve of *Ext Net Domestic Savings*. Finally, the bottom line is the GS (*Ext Genuine Saving II*), which is obtained by subtracting the value of resource depletion and pollution damages from Ext Net Domestic Savings.

Figure 3. Components of the GS as % of GDP, Taiwan, 1970-1998



The critical elements added by the green national accounting literature are to recognize natural resources as factors of production and environmental amenities as sources of welfare. A first question to be answered, therefore, is whether the calculation of depletion and degradation adds substantially to the picture of whether countries are on a sustainable path.

This reduces to the question of whether there are countries whose Net Savings rates are positive but whose Genuine Savings rates are negative, or vice versa.

For Taiwan, both Net Domestic Savings and Genuine Savings were positive from 1970 to 1998. However, before 1978, most of the yearly GS rates were below 20 percent of the GDP. During the 1980s, the average GS rates rose and represented around 28 percent of the GDP. Since1990, however, the average GS rates dropped to under 28 percent of the GDP. (See Figure 3).

The trends between Net Domestic Savings and Genuine Savings of Taiwan are similar through years. But before 1982, the Net Domestic Savings rates were higher than the GS rates; after 1982, the GS rates became always more than the Net Domestic Savings rates instead. From the previous illustration, we know that the factors affecting these two savings items are 'education expenditures' which stand for national human capital investments, as well as 'resource depletion' and 'environmental degradation' costs. Therefore, this situation indicates that, before 1982, the total value of Taiwan's natural resource depletion and environmental degradation was larger than that of its human capital investments, so the GS rates reached lower than Net Domestic Savings rates. Conversely, after 1982, the whole value of Taiwan's human capital investments was greater than that of its natural resource depletion and environmental degradation, so the GS rates grew higher than Net Domestic Savings rates.

For the UK, the formula for calculating its annual GS is:

GS=

Gross Domestic Investment + Education Expenditure + Current Account Balance After Official Transfers – Consumption of Fixed Capital (Depreciation) – Air Pollution Costs – Water Pollution Costs – Depletion of Nonrenewable Natural Resources – CO2 Damage Costs.

Again, we based on the following to compute the annual Taiwan-GS:

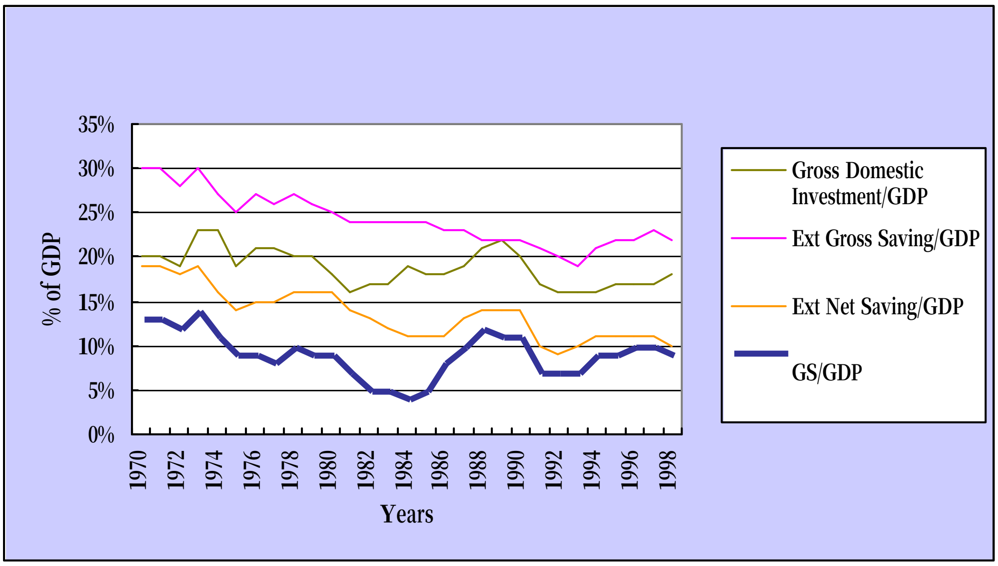
GS=

Gross Domestic Savings – Consumption of Fixed Capital (Depreciation) + Education Expenditure – Air Pollution Costs – Water Pollution Costs – Depletion of Nonrenewable Natural Resources – CO2 Damage Costs

In fact, either of the two formulas will do, since Gross Domestic Savings = Gross Domestic Investment + Current Account Balance After Official Transfers, as noted before.

So, through the compilation, the UK's result is shown in Figure 4 referring to the components of the UK-GS as shares of its GDP. The second top curve in Figure 4 is *Gross Domestic Investment*. Adding both education expenditure and current account balance after official transfers to Gross Domestic Investment, we get the top curve — *Ext Gross Savings*. Next, the depreciation of produced assets is subtracted from the top curve to give *Ext Net Savings*. Finally, the bottom line is the *GS*, which is obtained by subtracting the value of resource depletion and pollution damages from Ext Net Savings.

Figure 4. Components of the GS as % of GDP, the UK, 1970-1998



In UK, both Ext Net Savings and Genuine Savings were positive from 1970 till 1998. Table 6 then shows average annual ratios of the UK-Ext Net Savings[8] to the GDP and average annual ratios of the UK-GS to the GDP during the periods of 1970s, 1980s, and 1990s.

Table 6. Average Annual Ratios of the UK-Ext Net Savings to the GDP and Average Annual Ratios of the UK-GS to the GDP

	1970s	1980s	1990s
Average Annual Ratios of Ext Net Savings to GDP	16.7%	12.9%	10.8%
Average Annual Ratios of GS to GDP	8.8%	5.6%	6.8%

Therefore, the change trends between the UK-Ext Net Savings and the UK-GS are similar during the years. According to the calculation definition as noted before, the difference between these two savings items are 'resource depletions' and 'pollution costs'. Figure 5 gives the picture of how the gap between the UK-Ext Net Savings and the UK-GS changed from 1970 to 1998. The gap then stands for the value sum of the UK's 'resource depletions' and 'pollution costs'.

We can see that, in the UK's case, before 1983, the total depletion and pollution costs as percentage of the GDP were between 6% and 10%; after 1983, the total costs as percentage of the GDP decreased nearly every year. And from 1988 until now, the total depletion and pollution costs as percentage of the GDP only ranged between 2% and 6%. In these terms, we can conclude that the government's general environmental policy led to an improvement in the country's environmental degradation during the past 15 years. With regard to the detailed effects of these negative components of the GS, we will include the discussion in the latter section.

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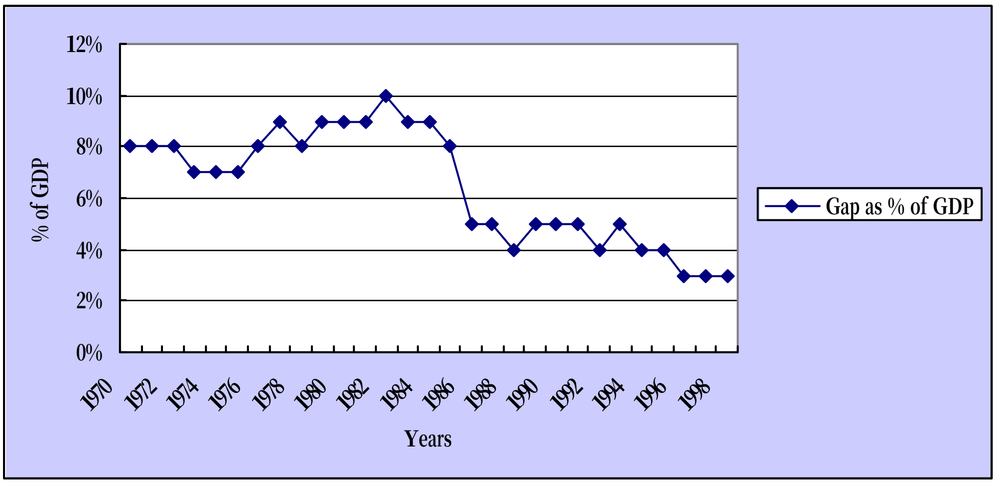
[8] Please not that the UK-Ext Net Savings has a different meaning position from the Taiwan-Ext Net Domestic Savings due to the difference in their definition.

Figure 5. Gap Between the UK-Ext Net Savings and the UK-GS, 1970 -1998



Component Effects in the GS

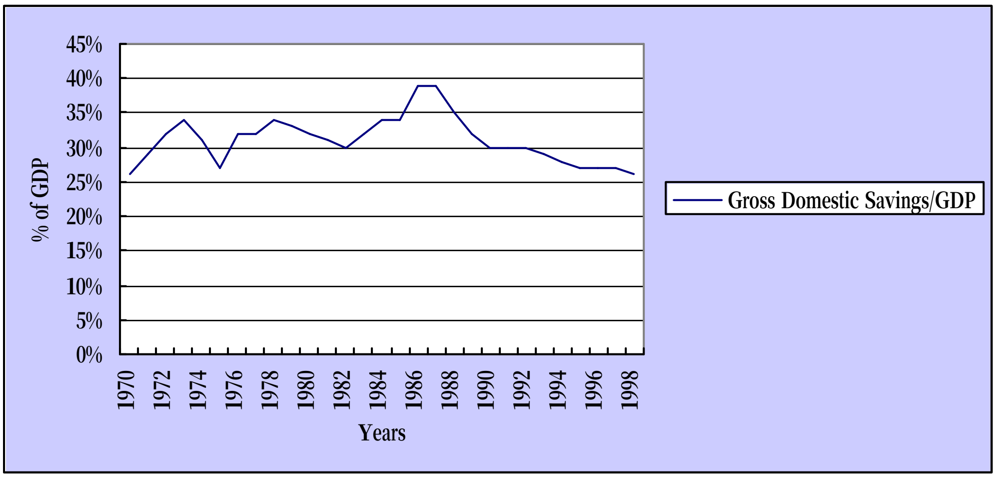
Given the differences of growth trends between GDP and GS as illustrated before, it is worth investigating which components have the most significant effects on the overall shape of the GS. The following is the analysis of the effects of both the positive and negative elements of the GS for the two countries.

Positive Items

Let's firstly look at the positive contributions to the GS — the basis for the index, *Gross Domestic Savings*, and human capital investment, *Government Education Expenditures*.

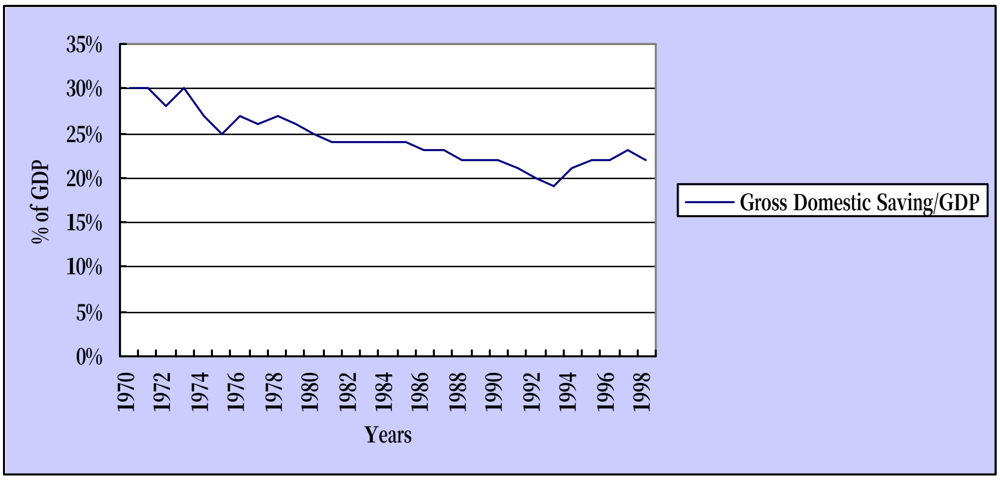
From Figure 6, it is clear to tell that between 1970 and 1973, Taiwan's Gross Domestic Savings as a percentage of the GDP increased steadily. Since 1973, however, the rates of Gross Domestic Savings went down. Afterwards, the Gross Domestic Savings rates had virtually no big changes until between 1985 and 1989. Since 1985, the savings rates rose more than before, then after 1988 the rates went lower again. Since the Gross Domestic Savings form the basis for the rest of the GSI, we would expect this effect to be passed through to the shape of the final index.

Figure 6. Gross Domestic Savings as % of the GDP, Taiwan, 1970-1998



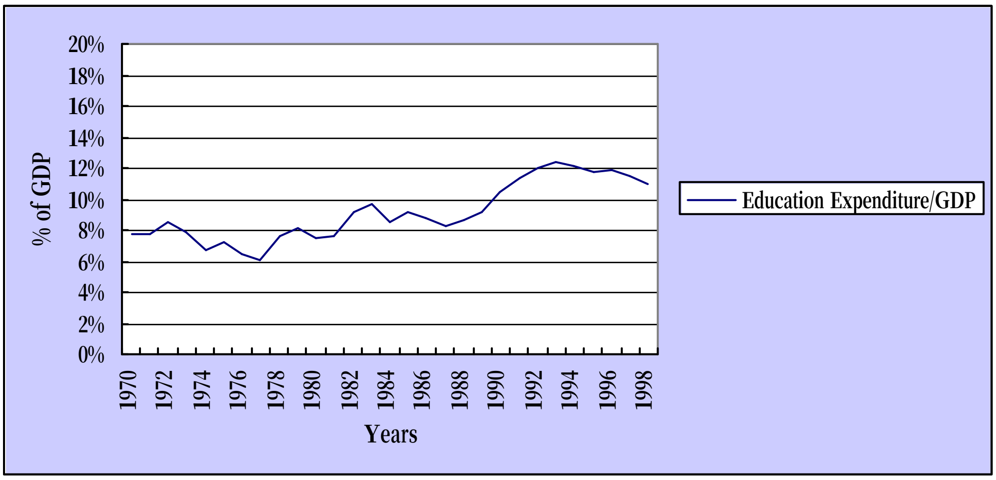
As to the UK's situation, from Figure 7, we can tell that the ratios of the UK's Gross Domestic Savings to the GDP fell steadily from 30% to 20% since 1970 till 1994. After 1994, the ratios then lifted a little again.

Figure 7. Gross Domestic Savings as % of the GDP, the UK, 1970-1998



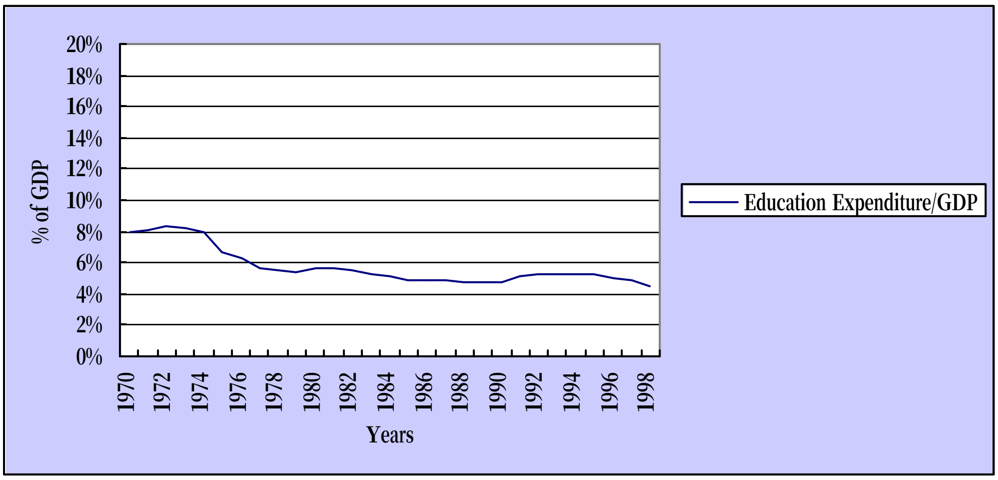
Regarding the changes of 'education expenditures' over the years, from Figure 8, we know that from 1970 to 1989, the ratios of Taiwan's education expenditures to the GDP fluctuated between 6% and 10%; from 1990 onwards, however, the ratios rose a bit and keep fairly stable at about 11% or 12%.

Figure 8. Education Expenditure as % of the GDP, Taiwan, 1970-1998



About the UK's education expenditure change situations, from Figure 9, we can see the education expenditure ratios to the GDP fluctuated between 4% and 8%. In fact, since 1974, the ratios almost kept on a downward trend all along.

Figure 9. Education Expenditure as % of the GDP, the UK, 1970-1998



Negative Items

Four negative elements are within the GS calculation — air pollution costs, CO2 damage costs, water pollution costs, and natural resource depletion. Let's have a look at their separate effects on the overall GSI.

From Figure 10, we learn that, for Taiwan, the negative contributions of CO2 damage costs, water pollution costs, and natural resource depletion are quite small over the years. Besides, Taiwan doesn't have such huge changes in natural resource depletions over the years; that's because prices of other natural resources for Taiwan don't change a lot, and its oil production was relatively quite low. The air pollution costs, however, are with an impressive decreasing rate over the years. That's probably because of Taiwan government's efforts in practicing related environmental policies (i.e., exercising the air pollution tax policy to reduce the air pollution emissions, also see Appendix 1) for improving the air pollution condition.

Table 7 presents Taiwan's average annual decreasing rates of the air pollution costs at an interval of ten years.

Figure 10. GS Negative Item Effects, as % of the GDP, Taiwan, 1970-1998

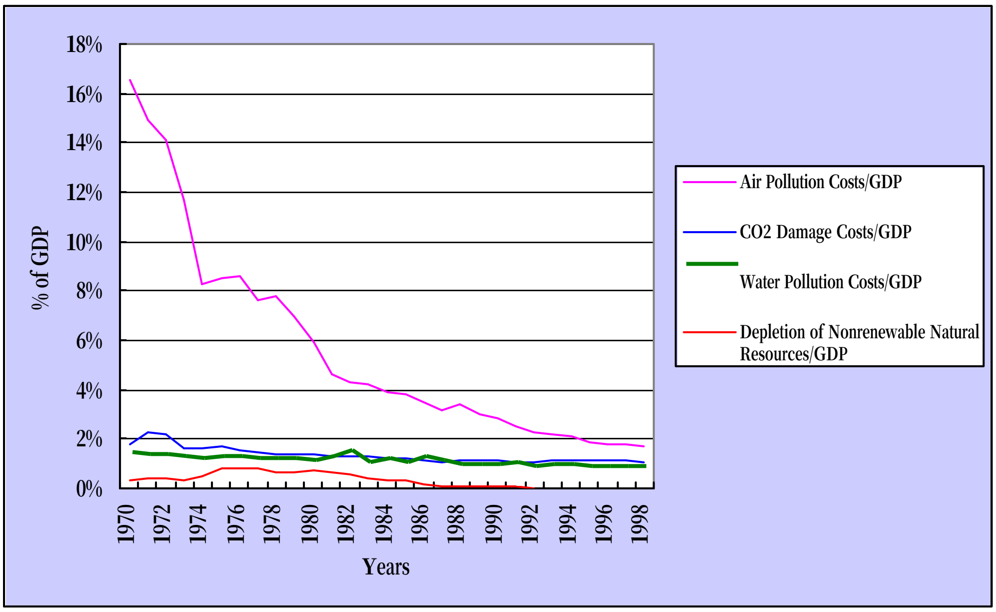


Table 7. Average Annual Decreasing Rates of Air Pollution Costs for Taiwan

Year	Average Annual Decreasing Rates of Air Pollution Costs
1970-1979	-9%
1980-1989	-7%
1990-1998	-5%

In UK's case, among the four negative elements of the GS, air pollution costs account for the first place of contribution in terms of the costs involved. (See Figure 11). But the ratio of air pollution costs to the GDP has dropped from 6% in 1970 to under 2% in 1998. Similarly, relevant actions of pollution control and defence have achieved the effect of improving air pollution condition. Table 8 presents the UK's average annual decreasing rates of the air pollution costs at an interval of ten years.

Figure 11. GS Negative Item Effects, as % of the GDP, the UK, 1970-1998

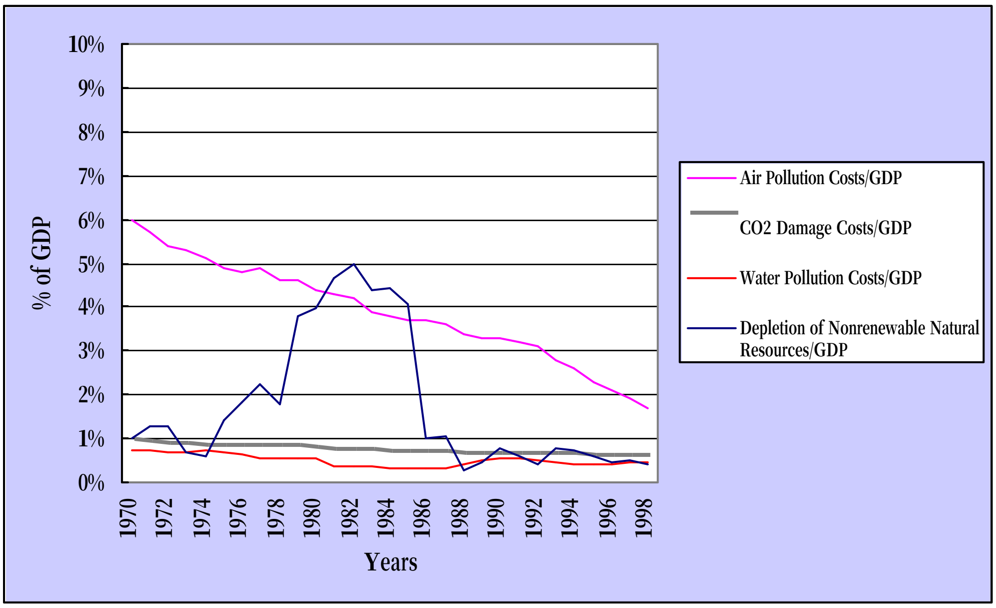


Table 8. Average Annual Decreasing Rates of Air Pollution Costs for the UK

Year	Average Annual Decreasing Rates of Air Pollution Costs
1970-1979	-2%
1980-1989	-3%
1990-1998	-4%

As noted before, Volatile Organic Compounds is the most damaging pollutant. However, the magnitude of the total cost values of air pollution emissions will obviously also depend on the quantity of each pollutant emitted. In this respect, in the case of UK, Carbon Monoxide is the most significant pollutant over the period. Sulphur Dioxide, on the other hand, either in terms of marginal social cost involved or the volume emitted, during the same period, has had important influences. However, emissions of this pollutant fall quite steeply between 1980 and 1990, probably because of country commitments with respect to the UN ECE [9] First Sulphur Protocol.

Figure 12 displays in more detail the degree to which the value of different air pollution damage has changed over the period. While damage caused by Volatile Organic Compounds, Nitrogen Oxides, Carbon Monoxide, PM10, damages are a steadily declining proportion of GDP, Sulphur Dioxide damages fall more dramatically.

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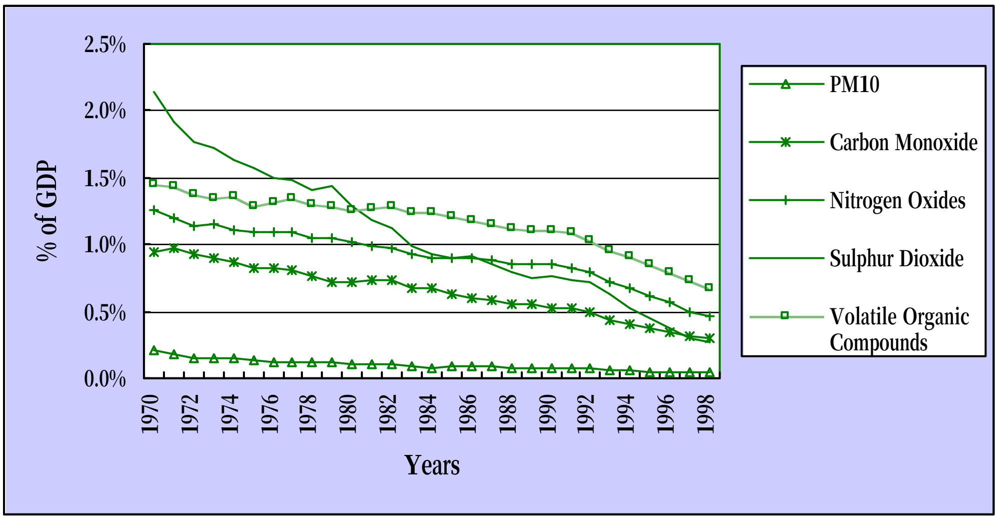
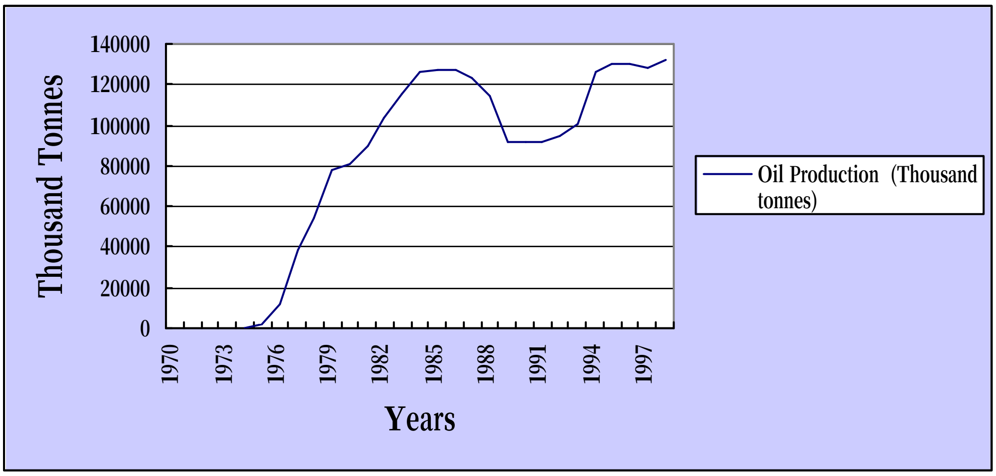
[9] United Nations Economic Commission for Europe.

Figure 12. Air Pollution Elements, the UK, 1970-1998



The second contribution of the negative effects is from natural resource with regard to the depletion costs incurred. In Figure 11, we can see that from 1970 to 1978, the ratios of depletion costs of nonrenewable natural resource to the GDP were between 1% and 2%. From 1979 till 1985, the ratios lifted to between 4% and 5%, and that's because the market prices for these natural resources became higher during the period, so the rents (costs) lifted higher as well. Another reason is that the total production (mainly oil production, see Figure 13) also increased during the period. From 1985 to 1998, the depletion ratios then dropped down to only between 0% and 1%.

Figure 13. Oil Production, the UK, 1980-1998



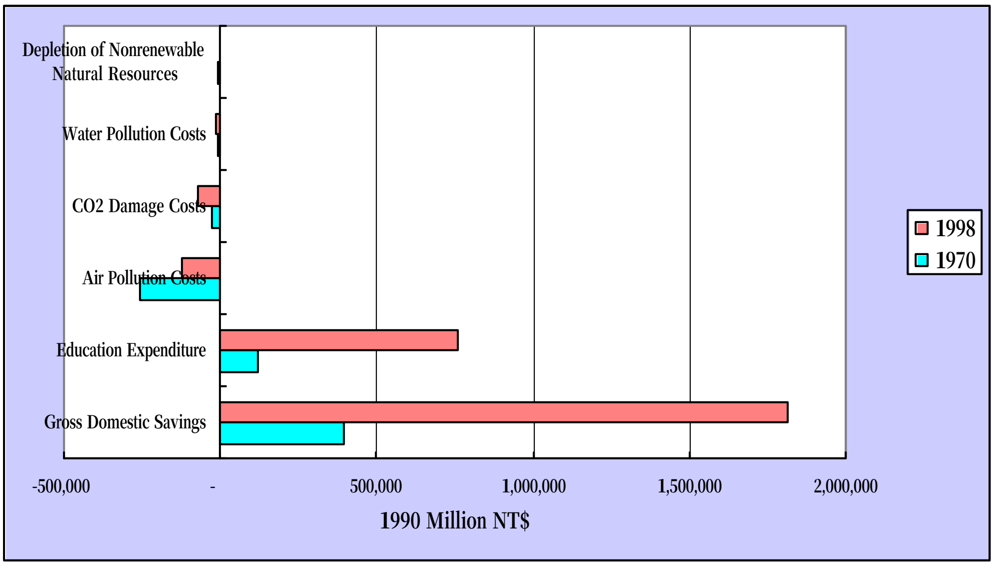
Data source: Department of Trade and Industry, the UK.

Robustness Analysis and Sensitivity Analysis

Robustness Analysis

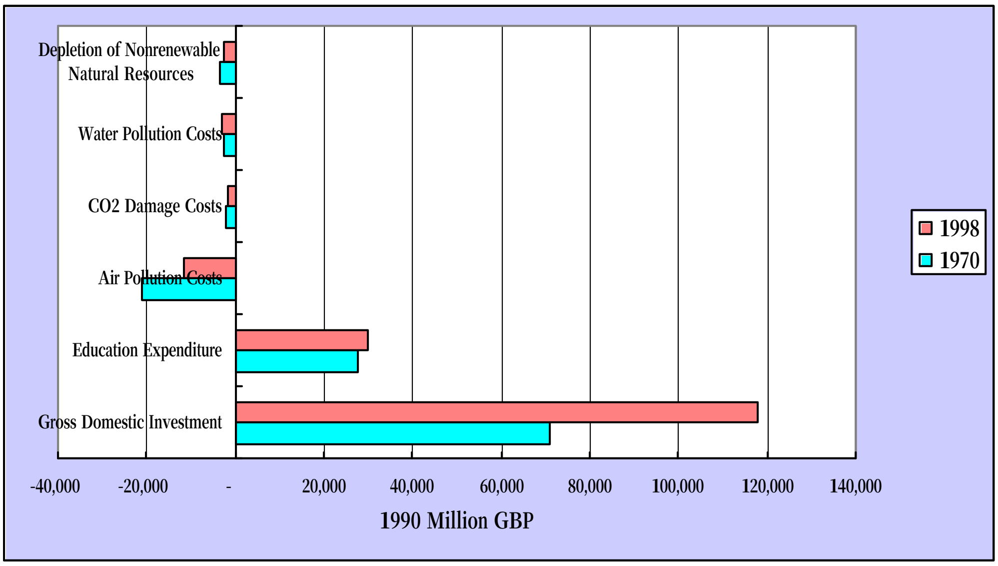
From the previous discussion, it has emerged that certain individual factors contribute more significantly to the GSI than any others. Figure 14 and Figure 15 summarizes the relative adjustments to Gross Domestic Savings (Investments) for Taiwan and the UK, for the two years 1970 and 1998: the beginning and end (respectively) of the study period. This graph indicates not only sizes of the contributions from individual items relative to each other, but also shows how those contributions have changed over the course of the study period.

Figure 14. Relative GS Component Values, Taiwan, 1970 & 1998



For Taiwan, as is to be expected from the previous discussion, both ‘Gross Domestic Savings’ and ‘Education Expenditure’ are seen to have a substantial positive impact and their growth rates are fairly high during the years. ‘Air Pollution Costs’ has a rather strong negative impact, but as noted before, due to the relevant environmental policy practice, the costs also decreased a lot over the period. Another negative impact arises from ‘CO2 damage costs’, which on the other hand slightly rose during the years. Less influential (negative) contributions are ‘water pollution costs’ and ‘depletion of nonrenewable natural resource’.

Figure 15. Relative GS Component Values, the UK, 1970 & 1998



In the UK's case, as we can see from Figure 15, both 'Gross Domestic Investment' and 'Education Expenditure' have positive impacts, but the growth rate of Education Expenditure between 1970 and 1998 was not very high. The largest negative impact is from 'Air Pollution Costs', too. However, likewise, the air pollution costs also somewhat lowered during the years because of environmental policy efforts. Less influential (negative) contributions are 'CO2 damage costs', 'water pollution costs', and 'depletion of nonrenewable natural resource'.

Sensitivity Analysis

From the above robustness analysis, for the main body of the GS calculation, there are certain specific features in the index which contribute considerably to the overall shape of the index.

So, they are: *Gross Domestic Savings (Investment), Education Expenditure, and Air Pollution Costs.* Other items have comparatively little influence. Since these contributions rely implicitly on quality (accuracy) of the data collected and specific underlying methodological assumptions, it is appropriate to investigate the sensitivity of the GSI to changes in the underlying factors.

In here we look particularly at the impact of data credibility for Gross Domestic Savings (or Investment) and Education Expenditure, and the impact of the methodological assumptions underlying the estimates of environmental degradation from Air Pollution.

Sensitivity to Data Credibility with Gross Domestic Savings (Investment) and Education Expenditure

Both Gross Domestic Savings (Investment) and Education Expenditure are directly derived from national statistical dataset.

The national statistics outputs are usually fit for the purpose as there is always a standard process to produce the data and to support the continuing improvement in the quality and value of these data outputs. That is, usually the government will conduct efforts in the data risk management and data quality control to keep the published data up to fairly acceptable quality. For example, it is a key component for quality assuring the UK national statistics as set out in the Government White Paper 'Building Trust in Statistics'.

Especially for the national economic accounts data, under the System of National Accounts (SNA), all the data outputs are produced through an internationally common calculation and compilation methodology. The data outputs then could be on an accordant base for international comparison and analysis.

In view of these, I would be relatively confident in using these published dataset as two series of inputs for calculating the GS in question.

However, national statistical outputs can not, by their nature, be of perfect quality, although they must be of adequate accuracy to fit their main purposes.

Components of risk relating to reliability are identified by considering the various elements of the statistical process from user consultation and development through to dissemination and archiving of the derived information. For each statistical process, the associated risks are identified in Table 9. It sets out the various stages in the statistical process and the risks that are considered at each stage.

Table 9. Statistical Processes and Associated Risks to Data Reliability

Activity	**Major Risks for Reliability**
Collection design	Inappropriate design e.g. sample too small, or suboptimally allocated, collection mode not optimal for type of questions, respondent burden too great
Testing and development (including questionnaire development, systems and procedures)	Inadequate testing to ensure data of high quality is available and provided by the methods and systems used
Estimation	Bias in estimation e.g. outlier identification, use of benchmarks and risks of model based assumptions
Dissemination of standard aggregate outputs	Risk of release being seen as being politicised; risks to timely dissemination of outputs; risks to accuracy of outputs resulting in flaws in the dissemination process
Dissemination of non standard aggregates	Risks to accuracy of outputs resulting in flaws in the dissemination process
Dissemination of non identifiable unit record data	Risks to accuracy of outputs resulting in flaws in the dissemination process

Source: UK National Statistics.

From the above, we know that the government published data still bear on some level of error risks by their nature. But we will say that these minor data errors caused by any of the above processes are uncertain and must have been lessened to a very low degree. So we don't think these effects will contribute greatly to the change of the final GSI. 5% of the bias range could be assumed.[10] Figure 16 and Figure 17 therefore present the Taiwan-GS and the UK-GS's sensitivity to the published data reliability.

Figure 16. Taiwan-GS: Sensitivity to the Published Data Reliability

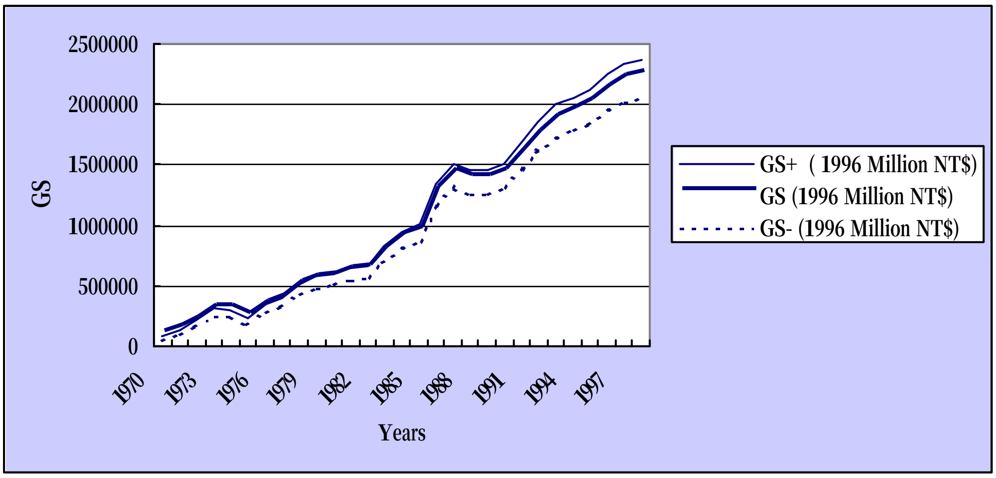
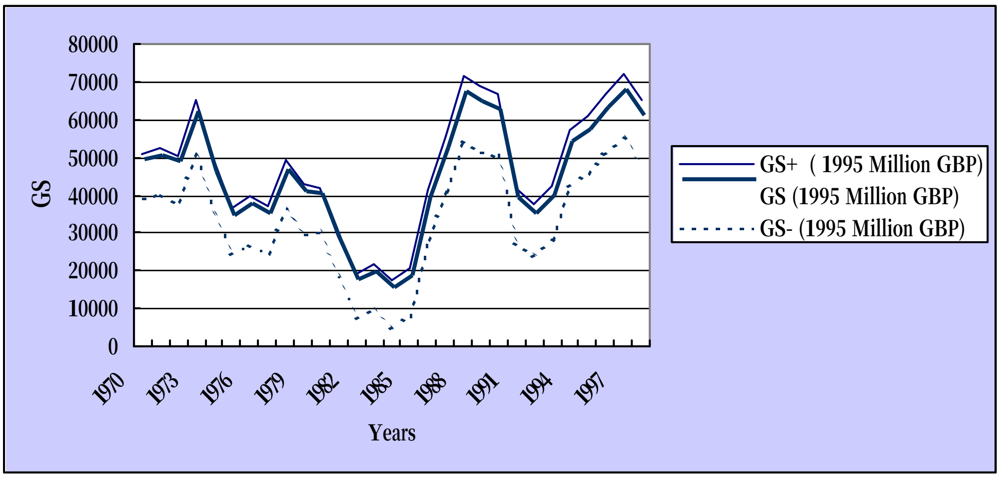


Figure 17. UK-GS: Sensitivity to the Published Data Reliability



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[10] The sensitivity range of the GS to the published data reliability varies from year to year. If we assume that 5% bias range is with the published data, then the *bias range of the GS for different year* will be " ± 5% *[that year's (gross domestic savings + education expenditures)/ that year's GS]".

So, due to some level of the uncertainty with the published data credibility, the sensitivity ranges of the Taiwan-GS and UK-GS during the period would fall between GS+ and GS-.

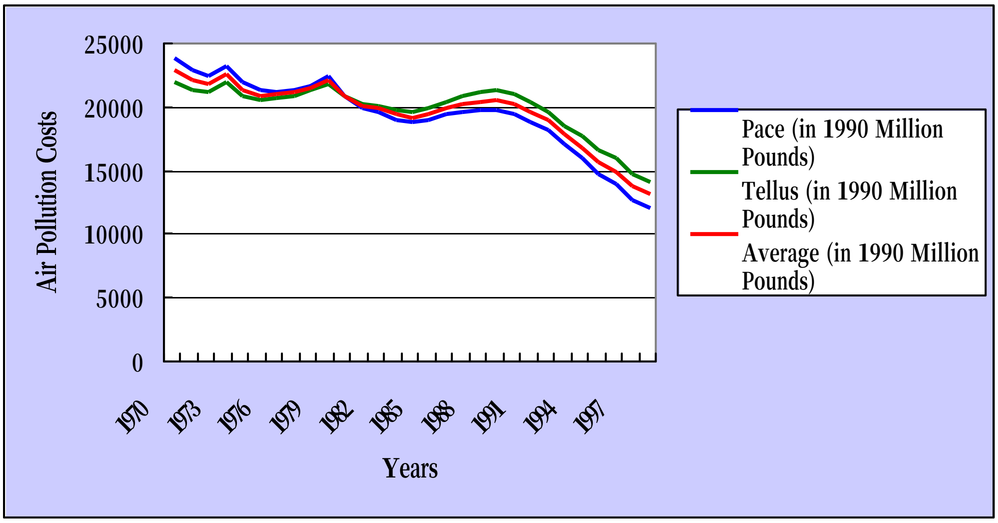
Sensitivity to Costs of Environmental Degradation (Mainly Air Pollution)

We mainly discuss here the sensitivity of the GSI to the costs of air pollution. The main reservation about calculating the air pollution values for each year is the assumption of the *marginal social cost*.

In the UK's case, we used the average value of two estimates (Tellus and Pace's estimates) as the input of air pollution social cost. As noted before, the Pace figures are essentially based on a review of the literature on damage costs. The Tellus figures are based on the control cost method of monetization. So, using these two separate estimates or using the average of them as assumption inceptions will lead to different outcomes of air pollution cost numbers.

Figure 18 illustrates graphically the possible UK air pollution cost results over the years caused by using difference estimates of marginal social cost.

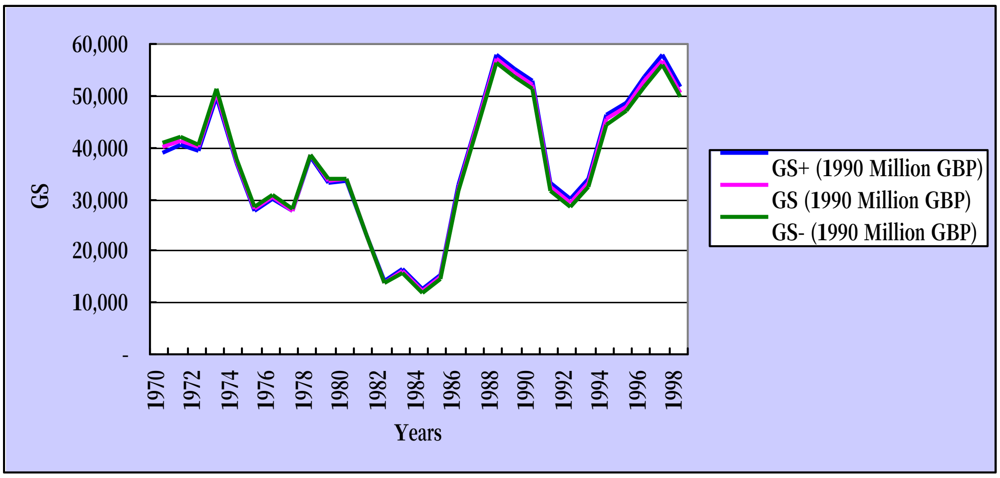
Figure 18. Comparison of Air Pollution Costs Using Different Marginal Social Costs, the UK, 1970-1998



These differences arise mainly because different costs are associated with the same pollutant in the different estimates, and the different pollutants show different trends in emissions as discussed before. In the Tellus estimate, the dominating cost elements are those associated with pollutants whose emissions are increasing. Taking the Pace estimates however, chiefly places greater emphasis on sulphur dioxide. Since emissions of this pollutant have fallen considerably over the scenario period, the overall costs of air pollution using the Pace estimates show a relatively smaller increase over the years.

As a result, different air pollution cost inputs will lead to different GS values. Figure 19 therefore graphically explains the sensitivity of air pollution cost to the GS over the years between 1970 and 1998 for the UK by adopting different social cost assumptions. And we can tell that the whole effect is not very big, no matter we use the Pace's assumption or Tellus's assumption.

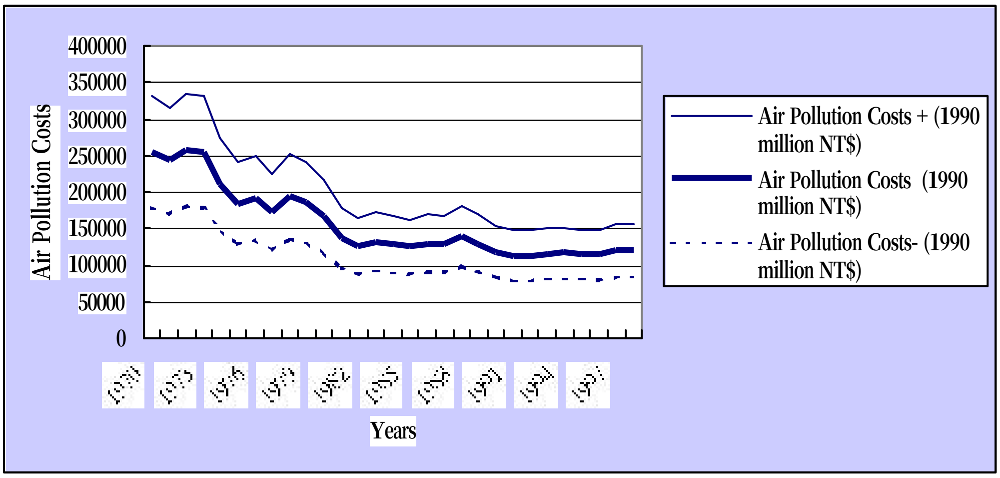
Figure 19. UK-GS: Sensitivity to Air Pollution Cost



Note: GS+ derives from using Pace's air pollution social cost assumption. GS- derives from using Tellus's air pollution social cost assumption. GS derives from using the average of both.

For Taiwan's air pollution cost estimation, the estimates of 'air pollution marginal social costs per unit of energy consumed' have a total range of 30 % uncertainty.[11] Figure 20 thus shows how the Taiwan air pollution cost estimation falls in an uncertain range (Air Pollution Costs+ and Air Pollution Costs-).

Figure 20. Uncertain Range, the Estimation of Air Pollution Costs, Taiwan, 1970-1998



And Figure 21, similarly, shows the sensitivity of air pollution cost to the GS over the years between 1970 and 1998 for Taiwan because of the uncertainty of the estimation of air pollution costs.

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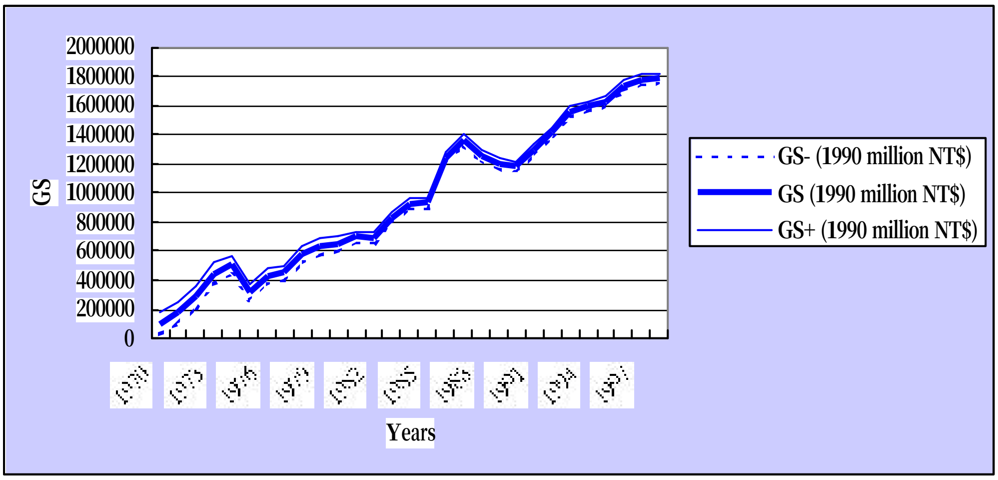
[11] Liang, Chi-Yuan (1993), "The Effect of the Environmental Protection Policy on the Economy of Taiwan." Far Eastern Meeting of the Econometric Society, Taipei, Taiwan.

Figure 21. Taiwan-GS: Sensitivity to Air Pollution Cost



Finally, other GS elemental items don’t really have influential impact on the shape of the index itself. That means, the sensitivity of those items to the GSI is relatively low. But what could be mentioned is that for the UK CO2 damage cost estimation, the PAGE95’s estimate of marginal impacts US$21 per tC is with a 90% uncertainty range of US$ 10-48 per tC. Figure 22 shows the uncertainty range of the CO2 cost estimation for the UK from 1970 to 1998. Figure 23 therefore presents the sensitivity of the CO2 cost estimation to the overall UK-GS from 1970 till 1998.

Figure 22. Uncertainty Range of the CO2 Cost Estimation, the UK, 1970-1998

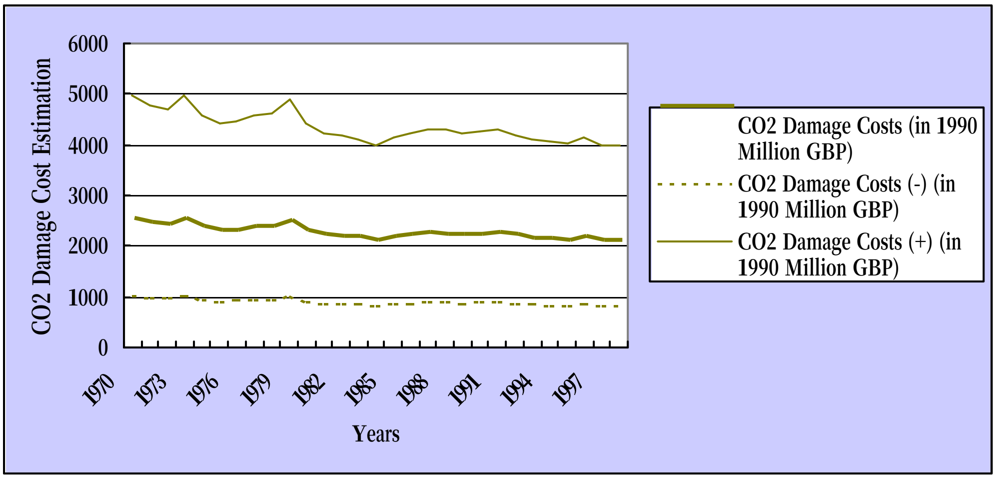
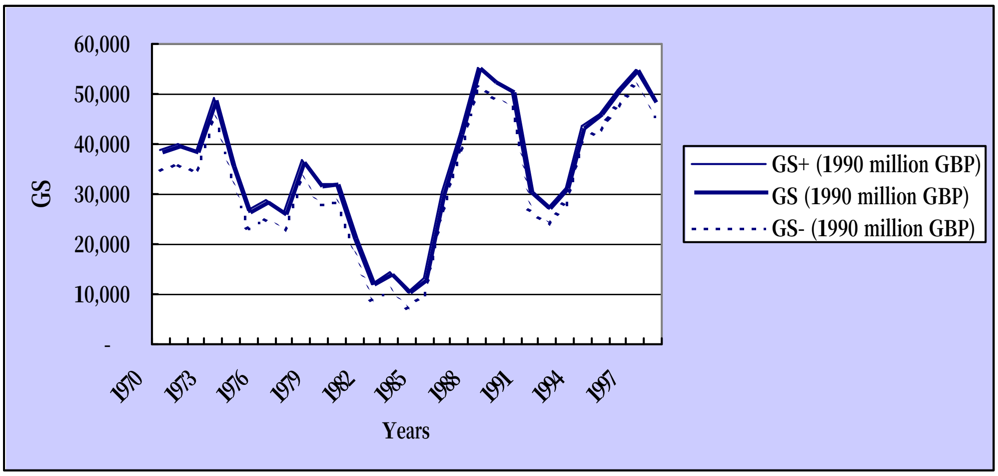


Figure 23. UK-GS: Sensitivity to CO2 Damage Cost



For Taiwan CO2 damage cost estimation, the social marginal impacts US$17 per tC is with a 50% uncertainty range.[12] For the natural resource depletion estimate, as noted before, it depends upon scarcity rents, which should be measured as price minus marginal cost of extraction (including a normal return to capital). In practice, however, marginal production cost data are almost never available, and practitioners[13] fall back on using average extraction costs. This will tend to overstate calculated resource rents and hence will understate the genuine savings.

Conclusion and Suggestions

The analysis in this case study of compiling the GSI has both policy implications and methodological implications.

On the policy side, it provides evidence that recent economic output - GDP levels - for both the UK and Taiwan seem to be sustainable. The comparisons of these two countries could also serve as an exploration as to national sustainable development assessment under different

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[12] Wei and Lee, 1997.

[13] For this item's data, I use the World Bank's. So the practitioners should be the World Bank's researchers.

level of economic development as well as country resource deposit situations. Therefore, as a resource-rich country, the UK's higher resource depletion rates and lower education rates to the GDP over years also depressed its GS rates during the period.

This result has been accordant with the prior research claims: Many resource-rich countries have achieved slow or no long-term improvements in their standard of living. One possible explanation is that they have failed to offset the depletion of their natural resource stocks with sufficient investments in physical (equipment, structures, infrastructure) and human capital (knowledge and skills).

Taiwan, on this side, however, appears to be in good shape. But in either case, actions could be taken to increase investment in reproducible capital to offset the depletion of natural resources as well as the depreciation of physical capital.

As the prior World Bank estimate didn't include the air pollution item, in this paper, by contrast, we have more detailed calculation leading to several essential results and analyses in this respect: Both countries had decreasing rates in the air pollution cost growth, from 1970 to 1998, and this is because of the practice of related environmental policy, as noted before.

On the methodological side, the analysis demonstrates that calculation of the genuine savings is feasible, at national level. The GS-related rates have also proved to be a group of friendly-used sustainability indicators. The above sensitivity analysis also increases the confidence we can have in those results: even though the issue of uncertainty is considered, most of the uncertainty falls into acceptable ranges.

Constructing projections for individual resources on the basis of detailed physical accounts and detailed analyses of future supply and demand conditions was beyond the scope of this study. It is probably well within the capability of resource management agencies in the countries concerned, however. More sophisticated projection methods than the ones employed in this paper are certainly possible.

Appendix 1

In order to reduce air pollution for the sake of environmental and human health, the government of Taiwan has taken some main measures in the past 30 years:

- Fuel use control;
- Air pollution tax levy;
- Emission standard setting;
- Emission amount control;
- Mobil source control strategies;
- Low pollution technology practice.

Obvious progress has been made in this respect and the following shall give some comprehensive examples.

The National Unhealthy Air Quality Station-Days Are Significantly Decreased

In the preliminary stage after the EPA (Environmental Protection Agency) was established (during the period of 1987 to 1991), the percentage of the unhealthy air quality station-days was about 16%. After the Air Pollution Control Act was promulgated in 1992, the EPA has actively promoted the pollution control works for industries and vehicles. In 1997, the percentage of the unhealthy air quality station-days was reduced to 5.46%, and the 6% target was achieved. By comparing the percentage with those in 1986 and 1987, the rates of progress were 15% and 68%, respectively. In 1998, the percentage of the unhealthy air quality station-days was further reduced to 5.09%. The significant achievements show that the air quality management tasks are moving toward a higher milestone in Taiwan. According to the stipulated targets of the National Environment Protection Plan, the percentage of the unhealthy air quality station-days will be reduced to 3% in 2001, 2% in 2006, and 1.5% in 2011.

National Air Pollutant Concentration Trend

According to the air quality monitoring information, PM10 and O3 are the main pollutants over the ambient air quality standards. After the promotion of the air pollution control tasks over the years, the air pollutant concentrations have reduced, and the human risk from air pollution has decreased. Based on the statistical analysis, the average annual concentrations of different air pollutants were all improved during the period of 1991 to 1999. Although the CO, NO2 concentrations were slightly increased in 1996 and 1997, the pollutant concentration trends were still improved in the recent five years. The rates of progress for average concentration of different air pollutants (from 1991 to 1999) are listed as follows: (Source: Air Pollution Division, EPA, Taiwan)

SO2: 40% (significantly improved);
PM10: 20%;
Pb: 25%;
CO: 21%;
NO2: 10%;
O3: 13%.

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