

Growth, employment and the environment

Bengt Kriström*

Summary

■ The first topic focused in the paper is the direct relationship between economic progress and environmental quality. Will economic growth improve environmental quality via technological progress and a rising demand for a clean environment as incomes grow? Or will the pressure on our ecological systems be ever larger, as incomes and consumption continue to grow? This article reviews some of the empirical literature on the so-called environmental Kuznets curve, which posits an inverted “U” relationship between emissions and the scale of the economy. A uniquely long time series on Swedish data to support this hypothesis is also provided.

The second topic of the paper concerns the environment-economic policy link: Is it possible to make changes in current taxation systems such that an efficiency gain can be secured? Is there a double dividend in terms of both an improved environment and lower unemployment? Some of the pertinent literature on this issue is discussed and recent work in Sweden is reviewed.

Three general conclusions follow. First, the relationship between environmental quality and the scale of the economy does not follow a general law; the empirical evidence is rather mixed on this issue. Second, there are no compelling reasons why revenues from environmental taxes should be earmarked (and used e.g. to cut taxes on labour). Finally, if environmental problems are regional or global, the benefits of international co-operation are considerable, and Sweden should actively seek such co-operative solutions. ■

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In recent years, economists have expended considerable energy on trying to understand the links between the environment and the economy. These efforts have been partly prompted by concerns of sustainability, i.e. whether or not positive economic growth is feasible in the long run. An early discussion of “sustainable development” is to be found in the writings of classical economists such as Jevons, Malthus and Ricardo. The pessimistic predictions of Malthus about the long run may be the best known of these forecasts. Jevons was concerned about the availability of natural resources in the future (and, as a precaution, saved paper in his basement).¹ Ricardo saw a future society in which the iron law of wages prevented human endeavour from improving living standards over the long run.

If an increasingly populated world becomes dominated by “western” consumption patterns, it is quite natural to ask whether or not the life-supporting processes that spring from our ecosystems can sustain the demands put on them. For example, the warming of the earth’s surface is now “undoubtedly real”, according to a recent assessment by the National Research Council (2000). The “hole in the ozone layer” and global reductions in biodiversity are other examples of how human impact on our natural environment *could* lead to serious consequences in the long run.

A second area of current interest concerns ways of finding revenue-neutral tax changes that would help to improve environmental quality and (above all) reduce unemployment. It is interesting to note that environmental taxation actually goes back to early ideas of taxing

** I am grateful to Lars Calmfors for his highly useful comments. Eva Rabinowicz and the participants at the Economic Council’s seminar on May 27th 1999 at the Swedish Ministry of Finance also provided a useful input. Since I have made additional changes, I am solely responsible for deficiencies that may remain.*

¹ Jevons’ book on “the coal question” from 1865 catapulted him into fame. He was concerned about the rate of coal extraction and was pessimistic about the possibility of obtaining cheap coal in the future, let alone finding useful substitutes.

pure rents from natural resources, such as the Henry George single tax (on land). If natural resources are given a wide interpretation, then environmental taxes can be viewed as taxes on the use of certain natural stocks and flows. Indeed, environmental services (waste disposal, recreational services, etc.) that we appropriate from the ecological system can be viewed as flowing from an environmental asset in fixed supply.² Basic economic principles hold that taxes on the rents that flow from assets in fixed supply are non-distortionary. Therefore, we intuitively expect that there is a scope for an efficiency gain, if current taxation systems are shifted towards environmental taxation and away from taxes on e.g. labour.

The first topic focused in the paper is the direct relationship between some measure of economic progress and environmental quality. Will economic growth improve environmental quality via technological progress and a rising demand for environmental quality? Or will the pressure upon our ecological systems be ever larger, as income and consumption continue to grow? A case can be made for symmetrically different answers to these questions.³ I review some of the empirical literature on the so-called environmental Kuznets curve, which posits an inverted “U” relationship between emissions and the scale of the economy. I also provide a uniquely long time series on Swedish data to support this hypothesis. The second topic of the paper concerns the environment-economic policy link: Is it possible to make changes in current taxation systems such that an efficiency gain can be secured? Is there a double dividend in terms of an improved environment and lower unemployment? I discuss some of the pertinent literature and summarise recent work in Sweden on this issue.

The paper is structured as follows. Section one provides a brief discussion about the environment and growth in a historical perspective. Section two is devoted to a simple exposition of how growth theory can be used to explain the relation between emissions and some measure of the scale of the economy. Both the “older” neo-classical growth theory and the “new” growth theory provide useful benchmarks for this discussion. Section three briefly reviews studies of the environmental Kuznets curve. In Section four, I turn to the

² See Heal and Kriström (1999) for a general dynamic model, where assets are given a wide interpretation and the implications of this interpretation are explored.

³ For an early economic analysis, see Keeler et al. (1971). They use a standard economic growth model, which generates a “golden” and a “murky” equilibrium, depending upon model parameters.

double dividend hypothesis. Space precludes a detailed discussion of the empirical and theoretical issues. I limit the discussion to a number of pertinent dimensions of the double dividend issue and illustrate it by using a number of recent studies that cover Swedish data. The final section concludes with an assessment of the relevant literature and distills policy recommendations.

1. Looking back

Environmental problems have been known for at least 2000 years. Erastotenes (300 BC) described how the felling of trees in Cyprus caused erosion. The logs were needed for military operations (war ships), to melt copper and in silver mining. Ponting (1993), an environmental historian, describes the peculiar environmental disaster at Easter Island. The story of Easter Island is just one of many similar episodes that show how interconnections between humans and the environment have led to dramatic changes of living conditions.⁴ In all probability, history will repeat itself and new environmental problems will be discovered in the future.

If we look back at the 20th century and ask how economists pictured the future, it seems reasonable to say that economists tend to be more optimistic than many other observers of societal development. Landes (1998) notes that “So, whereas historians are agnostics about the future, hence virtual pessimists, economists and business people tend to be optimists.” Partha Dasgupta (1993) pictures a future when “.. economic activities will be based almost exclusively on materials that are virtually inexhaustible..”⁵ Dasgupta’s optimistic vision contrasts starkly with the Malthusian predictions on resource scarcity by the so-called Club of Rome (Meadows et al., 1972). This report held a prominent place in much of the environmental debate in the 1970’s, which came to focus on resource scarcity issues. The simulations compiled by the Club of Rome suggested that we would run out of oil and other natural resources some time in this century.⁶

Kågeson (1998) argues, in a detailed analysis of resource scarcity, that there will be no essential shortages of any natural resources in the

⁴ Brander and Taylor (1998) provide a detailed economic analysis of the developments on Easter Island.

⁵ See also Radetzki (1995).

⁶ By contrast, Barnett and Morse (1963) show that prices of natural resources display a downward trend, which can partly be explained by technological progress (Romer and Sasaski, 1986).

near future (phosphorous may be an exception). There are several explanations supporting this hypothesis, although technological progress appears to be the most important.⁷ The use of copper is a particularly striking example of how technological progress brings substitution possibilities that are difficult to foresee. The rapid growth of telecommunications in the 1970s led many to believe that copper would be exhausted quickly. Fiber optics and other techniques has now made copper less important. Several other examples are available and they all point to the importance of the price mechanism. Indeed, the most important reason why the predictions associated with the Club of Rome appear to be too gloomy is the absence of any realistic price mechanism in the simulation models.

Since many of our most valuable natural resources and environments lack a market price, the market fails to be a catcher in the rye in those circumstances. This observation leads us into the “modern” environmental debate, which has come to circle around the husbandry of environmental quality (rather than natural resource scarcity) in the long run.

The Economist (1997) recently published an article titled “Plenty of Gloom”, arguing that most pessimistic predictions about the future have been wrong, in particular those about resource scarcity and a pending “ecological doomsday”. The article prompted the *Environment and Development Economics* to invite a number of leading economists and scientists to comment. In one of the comments, Hammitt (1997) points out that we should expect many “false alarms” when predicting environmental quality, because the underlying systems are complex. In addition, certain “alarmist” predictions have been correct. According to Hammitt (1997), the discovery of the ozone hole above Antarctica was initially dismissed as pure speculation (incidentally, this is also true for the effects of DDT).

Economic theory provides a number of useful ways of thinking about projects with irreversible and “serious” consequences, such as the “loss” of the ozone layer. Attached to an irreversible investment is an option value—a value of waiting—that is not necessarily picked up by conventional investment analysis.⁸ The option value can be interpreted as the value of (perfect) information. By postponing a project,

⁷ For example, technological progress in metallurgy has meant that more steel can be produced with less energy and materials. See e.g. *TIME*, Winter issue, 1997-98.

⁸ This is not altogether clear, however, since the standard present-value criterion allows for irreversibility, if suitably re-interpreted.

e.g. a hydropower construction, one may be able to learn more about the ecological and other consequences of the project. This benefit should be weighed against the extra costs involved that are incurred due to the postponement (i.e. foregone income). As shown by Fisher (1988), ignoring the prospect of new information can bias decisions towards development. It is empirically quite difficult to measure option values and there are only a few applications in the environmental economics literature. Fisher and Hanemann (1986) provide an illustrative example of a currently available strain of corn that may have future value. For additional discussions with examples from many different areas of economics, see Dixit and Pindyck (1993).

2. The environmental Kuznets curve

In its World Development report of 1992 (World Bank, 1992), the World Bank presented a number of diagrams that displayed relationships between environmental quality and measures of economic activity. The diagrams suggest that for some pollutants, countries seem to be able to “grow out” of environmental problems. Thus, while emissions grow at low levels of economic activity, there is a turning point after which pollution decreases. This relationship, or rather the associated curve, has been coined the environmental Kuznets Curve (EKC), after the empirical relationship established by Simon Kuznets regarding income inequality and economic development. Most of the current literature on the EKC is empirical and I will comment briefly upon it below. It will be useful, however, to begin by trying to disentangle the salient properties of the EKC within a simple model. I view the EKC as a particular form of equilibrium relationship, where technology and preference parameters determine the shape of the curve. In other words, the EKC is a reduced form.⁹

Let the utility function for the representative individual include two arguments, consumption and pollution. Utility is an increasing function of consumption and a decreasing function of pollution. In addition, it is assumed that neither good is inferior (increasing consumption possibilities increase the demand for consumption and environmental quality). Society's production possibilities are given by a production function, which has pollution and a technology parameter as inputs. Taking pollution as an input can be justified on several grounds. A simple and natural way is to think of pollution as propor-

⁹ Mathematical details of this model are given in Kriström (1998).

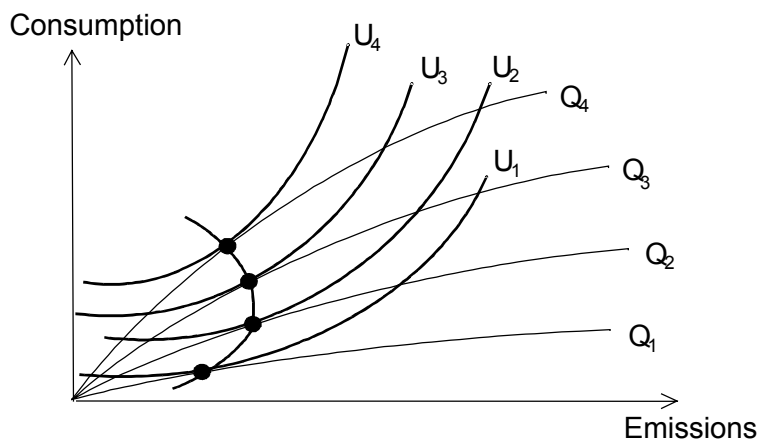
tional to a certain production factor (like oil). It would be simple to include capital and labour in the production function, but it is convenient to abstract from any detailed specification of the technology. For simplicity, I assume that technological progress is exogenous.

Maximising welfare subject to the technology shows that, at each point in time, the marginal willingness to pay for improved environmental quality should be equal to its marginal cost in terms of lost output along the optimal path. Thus, we can interpret the EKC as an expansion path, familiar from the theory of the consumer and the theory of the firm. The qualitative properties of this path determine the relationship between economic activity and environmental quality. The shape of the curve is determined by a *combination* of preference and technology parameters. Nevertheless, some authors seem to argue that the shape of the curve is driven by changes on the demand side. “The U-shape is consistent with a scenario in which industrial development initially leads to greater raw emissions, but net emissions eventually decline as concomitant increases in income raises the demand for health and environmental quality” (Holtz-Eakin and Selden, 1995). Grossman and Krueger (1994) are cautious about the interpretations of their findings on the EKC, but argue that the strongest link is “.. as nations or regions experience greater prosperity, their citizens demand that more attention is paid to the non-economic aspects of their living conditions.”

Figure 1 illustrates a possible shape of the EKC for four different periods of time. The figure resembles the familiar picture from introductory microeconomics of the backward bending supply curve of labour. If the substitution effect dominates the income effect, labour supply increases when the real wage increases and vice versa. A similar interpretation is possible in this model and I will return to it shortly, but let me begin by using Figure 1 to interpret the EKC hypothesis further. When the scale of the economy is “small”, pollution will be “insignificant”. As the economy grows, emissions tend to grow. At early stages of development the marginal utility of consumption is “high”, while the marginal disutility of pollution is “small”. As consumption grows, the marginal utility of consumption will decrease, while the marginal willingness to pay for environmental improvements will tend to increase. Technological progress guarantees that higher levels of production can be achieved, at any given

level of environmental quality.¹⁰ This observation leads to a decomposition of the changes into substitution and “income” effects in the following way.

Figure 1. The choice of consumption and environmental quality over time



Note: ($i=1, \dots, 4$) denotes different utility levels and Q_i ($i=1, \dots, 4$) is the production technology in the four time periods illustrated.

Technological progress means that the environmental costs of consumption decreases per unit of consumption. The substitution effect, calculated by holding utility constant and comparing combinations of optimal consumption-pollution bundles at time t and $t+1$, is therefore positive; both pollution and consumption increase. The income effect tends to increase both the demand for consumption and the demand for environmental quality. The substitution and income effects therefore counteract each other with respect to the pollution level over time although the former dominates the latter in the early stages of development. This process proceeds until society prefers environmental improvements, rather than potentially available increases of consumption. For example, Sweden introduced regulations on the sulphur content of oil at the beginning of the 1970s. Without these regulations, consumption could have been increased, but was “sacrificed” for the benefit of reducing sulphur emissions.

¹⁰ For a survey of the relation between income and the demand for environmental quality, see Kriström and Riera (1995).

It is to be noted that the shape of the EKC is not uniquely determined in this simple model. Without adding particular assumptions on preferences and technology, the curve may have virtually any shape. Even in this simple model, the interplay between preferences and technology is complex.¹¹

The model could usefully be extended in several directions. First, it is assumed that the interplay between the economic and ecological systems is completely known. This is a very strong assumption, given the fact that our knowledge of both systems is incomplete. The consequences of DDT and the “ozone hole” are examples of the fact that we do not have full information in practice. Second, I have assumed that society, at each point in time, strikes a correct balance between environmental quality and consumption demands. Deacon (1999) shows that the income-environment relationship is likely to vary across different political systems.¹² In particular, environmental quality is likely to be lower in non-democratic settings, if the political elite considers only the elite-specific costs and benefits of a certain policy. Since environmental goods often yield non-excludable benefits, one expects that relatively less will be spent on public goods by non-democratic governments. Deacon (1999) examines roads, public education and lead content in gasoline for a cross-section of countries. The data generally support the predictions of his theoretical model.

Stokey (1998) presents a model with exogenous technological progress to investigate the extent to which environmental considerations constitute long-run limits to growth. She finds that there are no limits to growth, in the sense that perpetual economic growth is possible without a disastrous impact on the ecosystem. A necessary condition for this result is that the marginal utility of consumption falls “rapidly enough”. Intuitively, households must be prepared to abstain from potential consumption increases “rapidly enough”; otherwise, pollution will grow with the size of the economy. Aghion and Howitt (1997) allow for endogenous technological progress in a similar set-up, where the number of innovations is proportional to the resources invested in the R&D sector. They prove that there is a path along which the development of the economy is sustainable. The condition is similar, but more general, than that found by Stokey (1998). For instance, there is an added condition on productivity growth in the

¹¹ For a proof, see Kriström (1998).

¹² See also Jones and Manuelli (1999).

R&D sector. In other words, technological progress is a necessary, but not sufficient, condition for sustainable growth.

Economic theory, not the least the “new growth theory”, suggests that technological progress plays a key role for sustainable development. This is not surprising, since economists have long advanced this kind of argument. However, modern growth theory allows a richer understanding of the key mechanisms that drive sustainable development. It also brings out the point that “zero growth” is not a necessary condition for “saving the environment”. Alas, the theory only provides the necessary conditions for sustainable development and is fairly thin on policy recommendations.

3. Empirical evidence

The World Bank 1992 study has been followed by a large number of studies, where the underlying theory and empirical models have been refined. The increasing availability of panel data has allowed researchers to follow the development of the key relationship across countries and time. Grossman and Krueger (1994) investigated the pollution-income relationship for several pollutants. Grossman and Krueger's sample included urban areas in 29 countries during 1977-88. They used annual median or 95th-percentile (peak) concentrations as the dependent variable in their regressions, and powers of per capita GDP, urban population density, and several other variables as independent variables. For sulphur emissions, Grossman and Krueger (1994) find that the turning point seems to lie in the 4000-5000 USD (GDP per capita) interval.

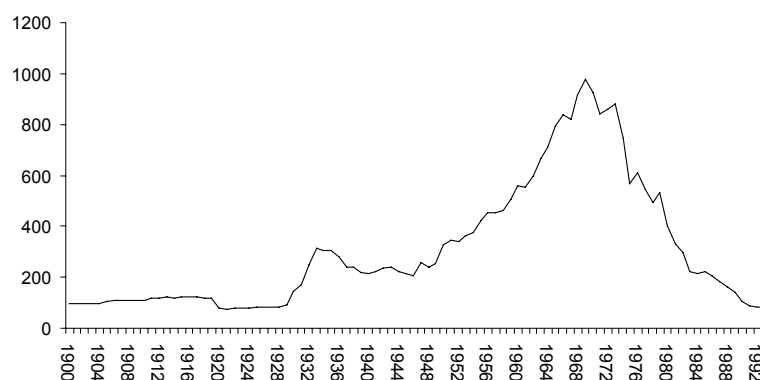
Shafik and Bandyopadaya (1992) analysed two indicators of river water quality; dissolved oxygen concentration and fecal coliform count. Oxygen concentration diminished as per capita GDP rose and the estimated relationship for fecal coliform had an inverted-U shape with a turning point of USD 1,375 (in PPP terms, at 1985 international prices). For incomes above USD \$11,400 the fecal coliform count increased with GDP. Shafik and Bandyopadaya (1992) also analysed a number of other environmental quality parameters. They conclude that the results are mixed. In some cases, it is possible for a country to “grow out” of an environmental problem, while other environmental problems seem to grow linearly with income. Selden and

Song (1994) and Holtz-Eakin and Selden (1992) provide similar analyses.¹³

3.1. An EKC for Swedish sulphur data

Current studies of the EKC are potentially marred by the fact that the time series used are relatively short.¹⁴ It seems useful to be able to follow a country over a longer period of time, i.e. in several stages of development. A unique time series for Swedish data is available that allows preliminary analysis of the EKC presented in Figure 2.¹⁵

Figure 2. Emissions of sulphur dioxide in Sweden (SO₂) 1900-93, 1000 tons



Source: Kindblom, Sjöberg and Lövblad (1993) and Statistics Sweden.

There is a marked increase of sulphur emissions in the early 1930's. Because of the depression in the 1930s, this is somewhat puzzling. A closer look at the data shows that the establishment of a large smelting plant can explain the increase. Ignoring the war period, the next dramatic change comes around 1950, after which 20 years of continually increasing of sulphur emissions followed. These years reflect a dramatic growth of the Swedish economy as well as the fact that envi-

¹³ The special issue of *Environment and Development Economics*, vol. 2, 1997, gives a useful summary of the literature on the EKC.

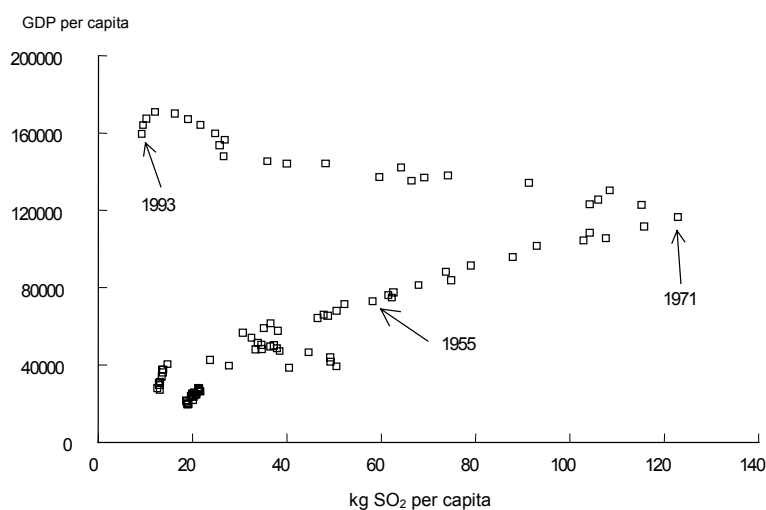
¹⁴ See Temple (1999) for a detailed analysis of the problems of using panel data for empirical studies.

¹⁵ See Lindmark (1999) for further discussion about this and similar data sets.

ronmental policy had yet to enter the scene. Swedish environmental policy was sparked by the discoveries made in the early 1960s on the link between sulphur emissions and “acid rain”. A comprehensive environmental law was subsequently established in 1969. This year also marks a turning point for sulphur emissions in Sweden. The oil crises of the 1970s and a rapidly expanding nuclear power program further contributed to the rapid decrease of emissions in that decade.

To illustrate the theoretical model, GDP and sulphur emissions for the period 1900-1993 are plotted in Figure 3.

Figure 3. The relationship between GDP and sulphur dioxide (SO₂) emissions in Sweden 1900-1993



Source: Brännlund and Kriström (1999).

Data thus support the notion that sulphur emissions grow during the early stages of development, but then decline for the reasons explored above. Clearly, technological progress, in the form of improved production processes and new energy sources (nuclear power) have been important on the supply side. An increased willingness to pay to reduce emissions have probably also made a positive contribution, assuming that this increase is mirrored in increasingly tighter environmental regulations on sulphur emissions (including a sulphur tax introduced in 1989).

4. Will growth solve environmental problems?

If the hypothesis underlying the EKC is true, it seems to suggest that we need to stimulate development, rather than curb it with various costly environmental regulations. This line of reasoning is, however, rather fragile. First, the character of the environmental problem needs to be taken into account. If the stock of pollution is the relevant issue (e.g. global warming), any turning point may come too late to effectively address the underlying problem. The same is true if the damage is irreversible. Second, there is an international dimension that must be addressed. If emissions decrease domestically, they may increase globally, which may be cold comfort if the environmental problem is global in character.

Arrow et al. (1995) argue that economic growth depends crucially on the resource base, in which environmental resources play a key role. If the depletion of the resource base is too rapid, this may impede long-run growth. In addition, they conclude that trade liberalisation and other efforts to improve the functioning of the economy are not substitutes for environmental policy. I would add that most current empirical analyses of the EKC are not based on structural models. Rather, some kind of reduced forms are estimated, which means that we cannot say much about the underlying mechanisms. It is not clear that estimated ad-hoc relations provide a useful basis for policy recommendations.

The discussion so far suggests that economic growth and environmental policy may go hand in hand. However, this is incompatible with the conclusion that environmental policy has played out its role. On the contrary, the role of environmental policy has been emphasised in recent years, partly following a search to marry together environmental and employment policy under the heading of the “double dividend hypothesis”. I now turn to this discussion.

5. The double dividend hypothesis

The intuitively plausible argument behind the double-dividend argument is that revenues from increasing a tax on a negative externality yields an extra efficiency gain, if those revenues are used to reduce distortionary taxes in the economy. Whether or not there exists a double dividend is, however, debated. This debate is complicated by the fact the notion of a double dividend is used differently by different authors. Goulder (1995) differentiates between three kinds of

double dividends. A *weak* double dividend exists if lump-sum replacement increases welfare (not including the environmental improvement). An *intermediate* form of double dividend materialises if it is possible to reduce some distortionary tax and obtain a welfare gain (not including the environmental improvement). Finally, Goulder (1995) defines a *strong* double dividend as the case when the tax swap always increase welfare, whenever a distortionary tax is lowered (again, the environmental benefit is not included). Starrett (1999) does not distinguish between different forms of double dividend, but attempts to disentangle the welfare impacts of revenue-neutral tax swaps in a second-best setting. Thus, a double dividend exists in this interpretation whenever a revenue-neutral tax swap increases welfare. An alternative interpretation is that a double dividend exists if unemployment is reduced and environmental quality is improved.¹⁶

In general, welfare analysis in second-best environments yields less clear results compared to the first-best setting. If there are no environmental taxes and a Pigouvian tax is introduced, this must yield an efficiency gain. If, however, all goods are taxed (including environmental goods), a revenue-neutral disturbance to the tax system is not necessarily welfare improving.¹⁷ If additional complications are added, one can appreciate why economic theory provides no clear-cut answer. Suppose that a carbon tax is introduced in a small open economy like the Swedish, and that the revenues are used to reduce taxes on labour. The extent to which emissions “move abroad” (via substitutions on the import and export side) depends on the technology in the import countries and other parameters.¹⁸ This example at least suggests that the welfare impacts of certain “green” tax swaps are not necessarily positive. In fact, any reform should be evaluated in relation to a number of dimensions. Some of those that have received attention in recent literature include:

- The structure of current taxation;
- the characteristics of the labour market;
- the character of the environmental problem (local/regional/global) and the benefits of reducing the environmental damage;

¹⁶ See Goulder (1995), and Park and Pezzey (1999) for additional interpretations and discussions.

¹⁷ See Starrett (1999).

¹⁸ For a review of the literature on leakage effects, see Hoel (1999).

- distributional impacts;
- adjustment costs and dynamic effects.

5.1. The structure of current taxation

Existing empirical and theoretical studies suggest that the structure of the prevailing taxation system is of critical importance.¹⁹ An important theoretical point is that an environmental tax can be viewed as an indirect tax on labour. Thus, labour supply will be affected, possibly in a negative way. This reduces the chance of an efficiency gain. In order to disentangle the mechanics of revenue-neutral tax reforms, one strand of the literature attempts to separate the economic impacts into two effects:

- The revenue recycling effect;
- the tax interaction effect.

The revenue recycling effect is defined as the efficiency gain of reducing a distortionary tax, as compared to returning the money lump sum. This effect is positive (in a welfare sense), because it is invariably better to reduce a distortionary tax, compared to returning the money lump sum (disregarding distributional issues). This follows from the definition of a distortionary tax: the social cost of a distortionary tax is greater than the revenues it yields. The tax interaction effect is subtle and can be positive as well as negative. According to Goulder (1999) it expresses the cost of increasing an environmental tax in a tax-distorted economy, compared to the same increase in an economy without distortionary taxes. Starrett (1999) shows that the interaction effect is linked to the indirect impact on labour supply, and suggests that it is likely to be negative.

In a number of recent papers, Bovenberg and De Mooij (1994), Bovenberg and van der Ploeg (1994), Bovenberg and Goulder (1996), and Parry (1995), it is claimed that the presence of a tax-interaction effect is sufficient to motivate an environmental tax that is *lower* than the marginal social damage at the optimum. Jaeger (1999) has recently challenged this literature, and argues that these papers contain a normalisation error involving the units used for the household budget constraint (net income) and the government revenue constraint (gross income). Jaeger (1999) shows that if this incompatibility is removed, the result is that the optimal environmental tax should be set *higher*

¹⁹ See Starrett (1999) and Goulder et al. (1997).

than the social marginal damage. Thus, according to Jaeger (1999), environmental taxes cause no additional distortions to the economy that would justify setting them lower than the Pigouvian level. While this is still a controversial issue, Jaeger's (1999) result is in line with the classical result of Sandmo (1975), in which it is shown that the marginal social damage should be added to the price of goods that cause a negative externality.

Existing energy tax systems often include a number of tax exemptions, which complicates the analysis of the double dividend issue further. Consider raising carbon taxes in Sweden in order to reduce labour taxes under the current tax structure. The current energy tax system includes a number of exemptions that must be considered. For example, the metallurgy sector is exempted from the carbon tax (in general, industry pays 50 per cent of the general rate). Since the metallurgy sector is exempted, carbon emissions will tend to increase from this sector, which is also the most "carbon-intensive" per SEK value added. In other sectors, we should expect a reduction of emissions, although the impact will be smaller than if the same tax applied to all sectors.²⁰ In addition, because of the leakage effects, global carbon emissions may well increase. According to Harrison and Kriström (1997), leakage effects are likely to be small in this case and their model projects a global decrease of carbon emissions from a unilateral Swedish green tax reform (the values assigned to trade elasticities are critical for this result).

Some additional comments on the structure of the tax system can be added. A standard result in public finance points to the problem of swapping narrow-based and broad-based taxes. Because environmental taxes are invariably narrow-based, the swapping of a narrow-based and a broad-based tax (on e.g. labour) does not necessarily increase welfare. Finally, since the purpose of environmental taxes is to reduce a negative externality, this erodes the tax base over time and thereby reduces the scope for decreasing distortionary taxes.

5.2. The labour market

If a "green" tax reform includes the labour market, we need to understand how the labour market will respond to such a reform. A first issue is whether a "green" tax swap can reduce unemployment.

²⁰ Brännlund and Kriström (1999) quantify these effects within Harrison-Kriström's CGE-model.

Bovenberg and van der Ploeg (1993) provide a model where this is possible, even in the long run. The result hinges on the assumption that the full tax burden falls on a fixed factor. Their result would seem however to be an exception. In general, one needs to take into account the fact that gains from a tax reduction are split between sellers and buyers (the extent to which depends on the relevant demand and supply elasticities). Nickell and Bell (1996) show that the correlation between unit costs of labour and labour taxes are weak in the 13 OECD-countries studied. Calmfors and Holmlund (2000) quote a number of studies that seem to indicate that lower labour taxes may not reduce wage costs. If correct, such results suggest that we should not expect a large impact on the labour market from a green tax swap.

Holmlund and Kolm (1998) argue that the effect of the replacement rate (unemployment compensation relative to the wage) is crucial in this context. If this rate falls under a green tax swap, they show that the impact on employment is positive. They go on to argue that a general labour tax cut (in Sweden) is unlikely to give rise to a significant impact on the labour market. Rather, the labour tax cut should be targeted at the service sector to be more effective in generating new jobs. A recent Swedish Government Commission (SOU 1997:11) has also suggested a targeted tax swap: higher carbon taxes and lower labour taxes in the service sector. However, selective tax cuts raise boundary issues, let alone problems of definition, and a “lock-in effect”, when labour is stimulated to move towards sectors with lower productivity. This, in turn, may have a negative impact on long-run growth. Harrison and Kriström (1997) provide an empirical evaluation with a computable general equilibrium model of targeted reforms for Swedish data. Their results suggest, as expected, that the service sectors would indeed be the “winners” of targeted, selective tax-swaps. However, the welfare impact is not found to be positive (but less negative compared to a general tax cut).

5.3. The character of the environmental problem

The character of the environmental problem has important implications for the choice of economic instrument. When the damage is independent of the physical location of the source, an incentive-based instrument is particularly advantageous. This advantage tends to diminish, as the damage becomes local in character, because it is much more difficult to construct efficient permit markets or pollution taxes. If the marginal environmental damages vary by location, then the ef-

efficient tax (and the market price for a permit) must vary. Brännlund and Gren (1999) show empirically how efficient nitrogen taxes would vary between different Swedish regions, depending on the soil characteristics of each region. In practice, such markets/taxes are invariably difficult (and costly) to construct and monitor. In such cases, regulations may be preferable.

If a tax swap is directed towards a local problem, leakage effects are irrelevant. Import substitution and “corporate flight” are examples of how the economy efficiently adjusts to a new price vector. The bottom line is that environmental improvements cannot be had for free. Rather, the challenge for environmental policy is to achieve environmental improvements in the least costly way.

5.4. Distributional impacts

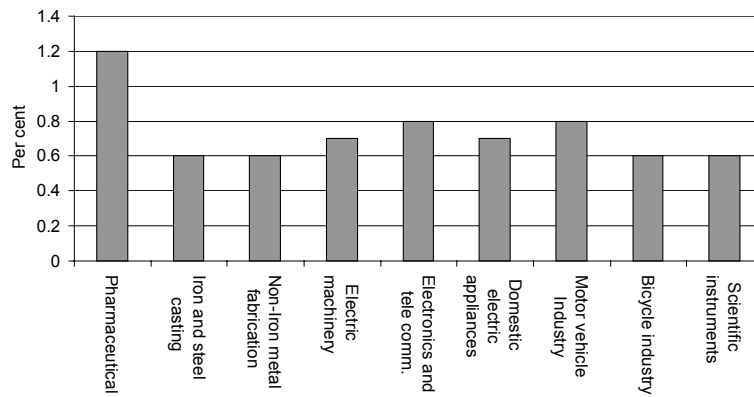
A green tax reform will create “winners” and “losers” both among firms and households. Computable general equilibrium models conveniently address such distributional effects, since they can handle the equilibrium repercussions in a consistent manner.²¹ I use the Harrison-Kriström (1997) model to illustrate simulations of a Swedish carbon/labour tax swap and begin with the results on the production side.²²

Figure 4 shows a number of sectors where value added increases when the carbon tax is doubled and used to lower labour taxes. The changes are small, around one per cent of value added. The increase is largest in the pharmaceutical sector, which is perhaps not surprising, given that labour costs are much more important than the costs of fossil fuels in this sector. A similar line of reasoning explains why value added increases in the telecommunication, scientific instruments and electrical appliance sectors. The telecommunication and pharmaceutical sectors are relatively large and according to the input-output table for 1992, they contribute 22 billion and 12 billion SEK respectively of value added. The motor vehicle sector has according to the same source a value added of about 43 billion SEK.

²¹ Examples of such studies of Sweden are Harrison and Kriström (1997, 1999) and Hill (1998). This section follows Ministry of Finance (1997) closely.

²² Partial equilibrium models described in SOU (1997:11) give similar results.

Figure 4. Examples of sectors where value added increases under a green tax swap (percentage increase of value added)



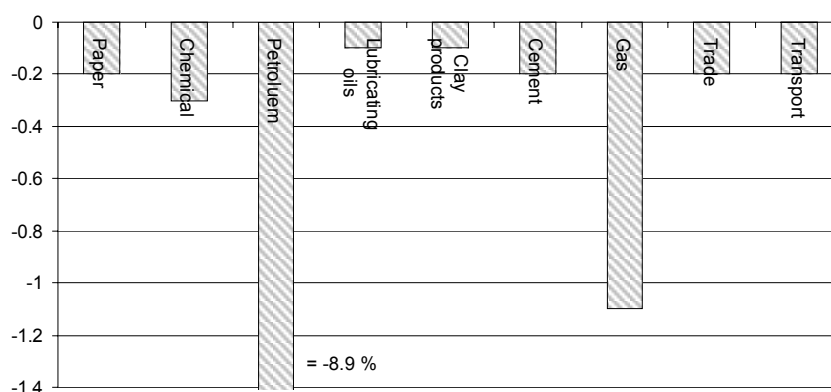
Source: Harrison and Kriström (1997).

It is interesting to note that the model predicts an increase of value added in the bicycles and motorcycles sector, which may be an easily overlooked consequence of the tax swap. An appealing interpretation is that households will use bicycles to a greater extent compared to other modes of transportation. More likely, however, the model picks up changes on the supply side rather than changes on the demand side. The results also suggest that labour costs are far more important for the car industry than the cost of fossil fuels. The lowered cost makes it possible for the car industry to expand in the world market. Export of cars increase by about one percent to the different export-regions, while the import of cars decreases, according to the model.

Figure 4 also provides certain information about the structural change of the economy, that is, how factors of production move from relatively less profitable to relatively more profitable sectors. This transformation is without cost in the model, though such costs may in practice be significant in the short run. To estimate the adjustment costs is very difficult, indeed.

The sectors most negatively effected by the reform are likely to be those sectors “producing” the goods that are subject to higher taxes, i.e. refineries. Figure 5 summarises the results.

Figure 5. Examples of sectors where value added decreases under a green tax swap (percentage decrease of value added)



Note: The carbon tax is doubled and labour tax replacement is used (percentage increase of value added).

Source: Harrison and Kriström (1997).

As expected, value added is reduced the most in the petroleum sector. This is a natural consequence of the fact that the demand for fossil fuels will be reduced when the prices increase. Among the other sectors negatively affected are cement and transportation. The cement industry and the transportation sector are relatively heavy users of fossil fuels. Value added also decreases in the retail sector (trade). Value added in the transportation and retail sectors amounted to SEK 79 and 132 billion, respectively, in 1992, according to the input-output table. Thus, even if the percentage changes are very small, the absolute levels of change may be large.

Turning now to the distributional effects on the household side, several studies on Swedish data are available. Hansson-Brusewitz (1997) uses a detailed micro simulation model to study the distributional impact of green tax reforms for Swedish data. His results confirm the hypothesis that taxation of fossil fuels tend to be regressive.²³ The distributional results of the Harrison and Kriström (1997) model, and those of a partial equilibrium model used by the Swedish Green Tax Commission SOU 1997:11, produce similar results to those presented by Hansson-Brusewitz. In particular, whether or not labour tax replacement is used makes virtually no difference. Therefore, I use

²³ See Smith (1995) for a review of this literature.

the results derived from the partial equilibrium model in SOU 1997:11 for illustration, since it allows for a geographical breakdown.

Table 1. Effects on different income groups of a 100 per cent increase of the Swedish CO₂ tax

Income group	Change in tax payment, SEK/capita and year	EV ^{c)} , SEK/capita and year	EV ^{c)} , per cent of total expenditures
1 ^{a)}	554	888	1.24
2	683	1110	1.10
3	744	1258	1.00
4	851	1451	0.94
5 ^{b)}	1026	1727	0.78

Notes: a) Lowest income. b) Highest income. c) EV = equivalent variation \approx real income change.

Source: SOU 1997:11.

Table 2. Effects on different household types of a 100 per cent increase of the Swedish CO₂ tax

Type of household	Change in tax payment, SEK/household	EV, SEK/household	EV, per cent of total expenditures
Not married, 0 child	951	1530	1.18
Married, 0 child	1492	2421	1.07
Not married, 1 child	1383	2217	1.14
Married, 1 child	1621	2790	0.99
Not married, 2 children	1498	2351	0.98
Married, 2 children	1660	2821	0.91

Source: SOU 1997:11.

Table 3. Effects on households in different regions of a 100 per cent increase of the Swedish CO₂ tax from a partial equilibrium model

Region	Change in tax payment, SEK/capita	EV, SEK/capita	EV, per cent of total expenditures
Southern Sweden	761	1318	1.10
Big cities ^a	813	1261	0.88
Major cities	765	1275	1.03
Northern Sweden ^b	752	1275	1.06
Northern Sweden ^c	778	1392	1.16

Notes: ^a) Stockholm, Gothenburg and Malmö; ^b) densely populated areas; ^c) thinly populated areas.

Source: SOU 1997:11.

Table 1 confirms the regressivity of the carbon tax, in the sense that the EV (the equivalent variation, i.e. the “real income gain”), as a proportion of expenditures, is highest in the lowest income group. Table 2 shows that the EV *per household* increases with the number of members in the household. If EV is calculated *per person* in the households, then it will decrease with the number of members in the household. Table 3 shows that the effects of the increased CO₂ tax also depend on the location of the household. Taken together, these results suggest that the tax burden will fall heaviest on those with low incomes and large families, who live in the sparsely populated part of northern Sweden.

The benefits from the tax increase, the value of the reduced CO₂ emissions, are more difficult to calculate than the costs. Though the value of reduced CO₂ emissions will be distributed roughly equally among all people, reduced petrol consumption will lead to a reduction of a number of other types of emissions. These reductions will largely benefit people living in the big cities. Examples of such environmental benefits are reduced noise from traffic, reduced congestion, and improved air quality—problems associated with densely populated areas.

It is interesting to speculate why the micro-simulation model, the partial equilibrium model and the CGE-model produce very similar results regarding the distributional impacts. The most intuitive explanation is that the reform is small relative to the size of the economy (a doubling of carbon taxes yields revenues less than one percent of

GDP and about one percent of total tax revenues). If prices in markets other than those directly affected by the reform are largely unaffected, we expect that a partial equilibrium model yields a useful first-order approximation. The fact that the distributional results seem to be quite independent of the choice of tax replacement could also be due to a poor representation of the labour market in the general equilibrium model. A perfect labour market is assumed and the labour supply wage elasticity is assumed to be equal across all household groups. Even so, the results presented here are not in contrast with those found in a majority of the currently available empirical literature, as reviewed by e.g. Goulder (1995), Ministry of Finance (1997), and Park and Pezzey (1999).

5.5. Adjustment costs and dynamic impacts

An additional dimension that may be considered is the long-run impact of a green and revenue neutral tax reform. Lundberg and Torstensson (1996) argue that such a reform may be benign to growth over the long run. They tentatively conclude that (my translation) “a tax swap promotes a structure of the economy that is associated with larger, rather than smaller, positive externalities”.²⁴ Their line of reasoning is based on endogenous growth theory. The positive externalities may take the form of knowledge transfers between sectors, such that the economy’s capital stock will be larger in the long run, compared to the status quo. There is, however, little empirical evidence that may be used to support this hypothesis. Furthermore, energy intensive sectors, e.g. the forest industry, may also generate positive growth externalities. For example, the Swedish forest industry has a leading position among firms developing “environmentally friendly” bleaching technologies.

6. Concluding remarks

Environmental quality and economic progress are not necessarily incompatible. Empirical evidence, some of it reviewed in this paper, suggests that certain environmental problems seem to be described well by the inverted “U” pattern suggested by the environmental Kuznetz curve. This does not necessarily mean that economic growth

²⁴ Lundberg and Torstensson (1996).

is a solution to our environmental problems; there is still a potent and important role for environmental policy. Indeed, standard economic theory suggests that under certain conditions there is a Pareto optimum if Pigouvian taxes are used with lump-sum transfers. Thus, from first principles we expect that environmental policy could play an important role when addressing current resource allocation problems.

Arguments that point to a potential marriage between environmental and e.g. labour market policy are less convincing. My view is that environmental policy should focus on efficient ways of reaching certain environmental goals. The fact that environmental taxes generate revenues that can be used to lower distortionary taxes is not a compelling argument for raising environmental taxes. Indeed, efficiency requires that a tax dollar should be used in such a manner that the marginal benefit is equalised across revenue sources. Tax swaps entail a kind of earmarking of tax revenues and enforce a constraint on the use of revenue. According to the Le Chatelier principle, an additional constraint on a set of available choices cannot improve an outcome. While lowering a distortionary tax *could* be the best use of additional tax revenue, ear-marking of tax revenues should be avoided. Nevertheless, whether or not there is a double dividend is a matter of controversy. When evaluating the double dividend argument, it would be prudent to scrutinise a large number of relevant dimensions. I have highlighted some of these dimensions: the structure of the current system of taxation; the functioning of the labour market; the distributional impacts; the character of the environmental problem as well as some of the dynamic aspects. Economic theory cannot give a definite answer to the question of whether or not a "green" and revenue neutral tax reform is beneficial in any given situation. It is important to note, however, that economic theory does not support the conclusion that all green tax reforms are worthwhile.

In conclusion, I believe that there is one robust finding in economics that can be fruitfully used in environmental policy, namely that there are benefits from (voluntary) co-operation. While space has precluded a detailed discussion of environmental policy in small open economies, some of the examples that I have discussed do point strongly to the usefulness of co-operation. I strongly believe that Sweden should continue to search for co-operative solutions,

whenever the character of the environmental problem calls for it, rather than moving along a much riskier, and potentially very costly, path of unilateral action.²⁵

²⁵ It is not easy to determine which path Sweden is currently following. The following Statement of Government Policy (14 September 1999) says that "Sweden leads the way in the transition to an ecologically sustainable society". But it also says that "Sweden's policy for sustainable development within the EU will be intensified. Global threats to the environment such as climate change and the depletion of the ozone layer must be solved in cooperation with other countries". (http://www.regeringen.se/regeringen/regeringsforklaring/tidigare_regeringsforklaringar/990914eng.htm)

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