Feature Article

GLOBAL WARMING AND THE SCOTTISH ECONOMY: CRISIS OR OPPORTUNITY?

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1. Introduction

No reader of this Commentary can be unaware of the major issues concerning the climatic changes resulting from the so-called greenhouse effect. Recent weather behaviour in Britain and other parts of the world has wreaked devastating consequences, and there is much debate about the extent to which these experiences can be attributed to the onset of long term climate change, as opposed to random drawings from the extreme tails of "normal" distributions of weather patterns. The cause of recent weather behaviour is, however, largely irrelevant, but its consequences do provide indicators of what we must expect in forthcoming decades. Furthermore, the consensus view from studies of global warming is that weather patterns are becoming more volatile, with increased probabilities of extreme outcomes. We now have reason to believe that this increased variability of weather patterns may be at least as serious (that is, more costly to human welfare) as the likely changes in the mean levels of temperature, rainfall and other climate indicators.

It is not the intention of this paper, though, to investigate the consequences of global warming. I assume on the basis of the best information available (represented by the papers of the 1988 Toronto Conference, for example) that the human welfare costs of unhindered global warming will be so high (if not for this generation, then certainly for the next and later ones), that action will have to be taken both to **prevent** some additional warming and to **adapt** to warming that will already have occurred. Furthermore, the magnitude of global warming damage costs will be so high that the majority of technically feasible solutions (or at least ameliorative measures) will generate positive net returns to society.[1]

If these axioms are correct, then there is no need to assess each policy proposal for economic viability. That does not mean, however, that every feasible project to limit global warming should be undertaken. Such projects are costly, and so it is important to choose a package of measures that is the least costly for achieving any target level of limitation. In other words, we should choose cost **effective measures.** One aim of this paper is to provide some insight into how this cost effectiveness may be assessed.

These types of question are typically addressed at a global or international level, or even in abstraction from any geographical/political context. This is unfortunate because responses will, for the foreseeable future, of necessity have to emanate from existing political structures, and analysis needs to be set in an appropriate institutional context. A second objective of this paper, therefore, is an examination of the role that Britain, and more particularly Scotland, can play in devising and implementing projects that can contribute to limiting the damage caused by global warming.

Our final focus is upon the Scottish business and personal sectors. What forces will be operating upon Scotland's businesses and households, and more importantly perhaps, what opportunities are likely to emerge for these groups in the future? The economy is about to experience major structural shifts resulting from both global warming itself and the responses made here and elsewhere to this process. Because these structural adjustments will occur relatively slowly, they will be difficult to identify until after the event; however,that slowness of change may well be to the advantage of any economy which can take anticipatory action, and exploit the new market opportunities which will be opened up.

We have ample historical evidence that "crisis" and consequent major structural change, provide opportunities for major improvements in living standards. The rapid growth of post war Germany

and Japan illustrate these opportunities. The crucial difference between future growth and that of the world economy in post war years is that the former will only be possible on a long term basis (ie, sustainable) if the energy emissions to output coefficient is substantially reduced. Some indirect evidence on the possibility of achieving this is given in the April 1989 edition of Energy Policy. Energy intensity (ie the ratio of energy consumption to output) fell by an impressive 20% in the European Community in the period 1973-1982, the period when oil prices rose very rapidly. However, in the period 1982-1986, this index fell by only 2.4%, and actually rose in four member states. The pressure of high energy prices appears to have been important in increasing efficiency; in the probable absence of high prices for the immediate future, another impetus to efficiency will be required.

As will be explained below, I believe that the technological base of the Scottish economy puts it in a strong position to take advantage of these opportunities for sustained growth. Whether this potential is realised is a matter for speculation, but recognition of possibilities clearly enhances that likelihood.

2. Global warming, and the Scottish economy

Before we turn our attention to the central themes of this paper, outlined in the Introduction, a brief diversion is in order. Predictions from global warming models relate typically to highly aggregated portions of the world, and it is well known that present modelling capabilities do not allow detailed pictures to be built up of the climatic changes likely to occur for small geographical areas. For Britain, this uncertainty is compounded by the fact that our climate is strongly affected by proximity to ocean currents and the extent and type of cloud cover; in each of these cases, climatological modelling is at its most uncertain.

We are thus not certain of even the direction of change of Scottish climate, let alone the magnitude of the likely changes.[2] Furthermore, this uncertainty is even more acute when one attempts to map likely climate changes into physical and economic consequences. Given this ignorance about even the direction of change, is it prudent to do anything at this stage? The answer must be in the affirmative for several reasons. Three of these will be mentioned here.

(1) The earth's atmosphere, and the energy and material flows between the earth, atmosphere and sun have certain self regulatory properties. We may liken the atmosphere in particular to a thermostat which regulates global climate. However, once the forces operating within the system interfere with the ability of the thermostat to perform its control function, serious consequences can ensue. These consequences will be serious irrespective of the direction in which the disturbance occurs.

Thus if Scotland becomes markedly colder and wetter (which cannot be ruled out) the economy, which has evolved over a very long period to the prevailing, largely unchanging climate pattern, will face major costs of adjustment.

(2) Even if Scottish climate did NOT change, the climate will change elsewhere. Our economy is not closed to the outside world, but is heavily integrated with it. Major changes elsewhere will feed back through international trading relationships; the patterns of demand and supply, and the prices at which trades take place are all subject to large uncertainties. However, the appropriate response to uncertainty is very rarely to do nothing.

(3) Although Britain (and even more so Scotland) acting in isolation may have relatively little impact on global warming, effective preventative action will require a concerted international effort that will have to be supported in resource terms by richer economies. If Western economies fail to undertake appropriate actions, it is difficult to see how other nations can be persuaded to undertake policies which will be more costly for them in real terms, given the pressures of economic development facing those economies.

3. Cost-effectiveness, and policies to limit the damage caused by global warming.

An essential prerequisite to the design of cost effective policy measures is a consistent set of accounting principles that allow identification

of the true costs and benefits of resource use. For market economies like that of Britain, personal and business decision makers are concerned with the costs and benefits they derive from certain actions. If all resources which are in any sense scarce[3] had a price, and each price correctly reflected scarcity and demand, then market decisions might well be optimal. Let us illustrate this point. Think of a power station emitting a greenhouse gas as a by-product. This emission is reducing the ability of the atmosphere to regulate global temperature, and so incurs a real cost to society. If the power station can freely emit the pollutant, it will do so if that is a consequence of the production technique it finds most profitable. Now imagine the power station had to pay for the use of the atmosphere as a dump, by an amount equal to the real cost borne by society from that pollution. One would then expect the factory to invest in pollution-saving equipment provided its cost were less than the emission damage. Thus an incentive is created to reduce pollution. Furthermore, the more polluted the atmosphere, the greater will be the social cost of additional units of pollution, and so this incentive will intensify the more polluted the environment becomes.

It follows that if prices for all resources, goods and services were "correct" in this sense, the need for additional preventative or corrective action by public bodies would be much reduced. Any good or service produced by an activity which is seriously damaging would have a price reflecting that damage. This would ration the purchases of the good or service, thus limiting the damage. One important role that government should play, therefore, is to establish a system of subsidies or taxes which bring market prices into line with the "true" social costs of the goods or services in question. Such a strategy has recently become popularised in the Pearce Report (Pearce et al, 1989), although the advocacy of optimal pollution taxes/subsidies has a long history in economic theory. (The Pearce Report also provides an excellent and non-technical discussion of the accounting framework just mentioned, and of appropriate policy design when actions have environmental consequences).

The present government has made a limited commitment to pursuing this path, but few steps have yet been taken. The pace of global warming changes also suggests, however, that even with an optimal pricing system (which would be very hard and time-consuming to devise), positive action by policy makers is required now to expedite desirable adjustments. What sort of action should this be?

One way of approaching this problem is to ask the following question:

What is the cheapest way of achieving a given target reduction in greenhouse gas concentrations in the atmosphere?

If we knew the answer to this question, then it would be sensible to concentrate efforts (at least initially) on pursuing that method. For example, evidence collected by the British based *Association for the Conservation of Energy* suggests that **energy conservation** is considerably cheaper, pound for pound, than substituting alternative, less polluting forms of fuel for present fossil fuel in power generation. We could similarly rank all feasible projects for reducing pollutant concentrations in this way. A major research programme involving the Departments of Economics and Energy Studies at the University of Strathclyde is currently researching this question.

Of course, problems such as this are much more difficult to address than one might first think. A few examples will suffice to illustrate this. There is, to begin with, a question of scale. We suggested above that energy conservation appears to be cost effective, based upon previous experiences of conservation programmes. But it is likely that the gains from conservation are higher for initial efforts than subsequent ones. In other words, we cannot expect to achieve total savings from conservation in simple proportion to the amount of it undertaken. A recent European Commission publication (EC 1988) stated:

In contrast energy conservation has revealed an unexpectedly large potential, surprisingly easy to tap through price mechanisms or simple energy policy measures. Uncertainties exist as to the remaining potential offered by energy conservation now that the easiest measures have been taken.

Take wind energy as a second example. We have reason to believe that wind energy is now competitive in cost terms with fossil fuel power generation; when adverse environmental effects are taken into account, wind energy is probably

cheaper at the margin.[4] However, for a small area like Scotland, the amenity losses (in terms of visual damage etc.) are likely to rise sharply with scale of land area devoted to wind turbine farms. These types of consideration suggest that it is not possible to devise a uniquely "best" package, independent of the scale of project proposed.

Secondly, and perhaps more important, we need to consider spatial locations of projects. Clearly solar power is unlikely to be economically desirable for large scale industrial energy generation in the UK, whereas it may well be in the Middle East. It may also be the case that £1 billion spent on emission control in newly industrialising countries is more effective than the same sum spent on the best available project in the UK.[5] A further example of this spatial dimension concerns reafforestation schemes. The scope for reafforestation in Britain is severely limited, no matter how desirable that may be. (It is interesting to note that in its current planning programmes, the Forestry Commission in Scotland places considerable emphasis on the potential benefits to the economy of tree planting and consequent fixing of atmospheric carbon). On the other hand, such an option has much to recommend it in many areas which have suffered major loss of tree cover. If reafforestation schemes could be coupled with the provision of wood for domestic and industrial energy in developing countries, this would provide a substitute to the fossil fuel that might otherwise be used, and so allow a more sustainable form of development. (The scale of this potential is seen when one realises that over half of all energy production in the African continent derives from fuelwood. Considerable scope exists for supplying future energy needs from fuelwood plantations, and small but efficient boilers could allow for this to be generated in a relatively clean way).

In conclusion, it seems that for the moment policy makers must operate in a position of great uncertainty regarding the consequences of global warming and the benefits to be derived from any particular policy measures. Gradual action begun now will almost certainly be more cost-effective than rapid adjustments made at later dates, but it is important to ensure that actions pursued are cost effective, thus giving the greatest value for money for what will inevitably be very costly actions.

4. The Scottish contribution to limiting global warming

The "solution" to global warming (assuming one is devised) will need to be the outcome of an international consensus, from which a programme of measures is designed that takes advantage of regional comparative advantages. Given also that many developing countries face acute difficulties in providing acceptable living standards from existing levels of income, one cannot expect these countries to place high priority on conservation measures during their industrialisation processes. But it is essential that such development is done in ways that are as unprofligate in terms of energy usage and inefficiency as possible, and this can only be achieved if substantial transfers of resources (including technology) are made from more affluent economies.

What do these general remarks imply for Scotland? As an affluent society in global terms, it must expect to contribute resources to other countries in return for agreed limitations in emissions. This should not be seen as charity or foreign aid, but instead as payment for external benefits received from such emission control. These resource transfers will not necessarily comprise general financial transfers, but could be packages of appropriate capital and technology that allow more efficient use and generation of energy, better control of emissions, and development and applications of alternative energy sources. As will be argued in the next section, the Scottish economy should attempt to build competitive strength in these activities, and orientate this advantage towards international markets as quickly as possible.

Unlike much previous "technology transfer", in which the actual transference of know-how has been limited (whether by design or otherwise), the aim should be maximum transferability. This suggests using joint ventures or other interactive organisational forms rather than "turnkey"projects, and also implies that government may need to compensate private firms which voluntarily lose monopoly control of expensively acquired technical know-how. in other words, the fact that technical know-how is a public good (in the economics sense of that term) should be exploited, rather than being seen as a justification for industrial secrecy.

None of this means that we can ignore reducing

emissions in the domestic economy. Effective response to the problem of global warming cannot afford to wait until co-ordinated action begins, nor should it be limited in scope to the scale of such common action. Much scope exists for adopting renewable energy on both large and small scales, for filtering engine and factory emissions more thoroughly, for improving thermal efficiency of buildings and so on. (One example, reported by Offgas, the government's gas industry watchdog may suffice. Less than 1% of the 11.5 million gas central heating boilers installed in UK homes use gas condensing boilers. These emit one third less pollution than old generation boilers, but at £150 more than rival systems, would reach payback within three years on average).

Many of these measures can be undertaken now with no additional net cost (witness the rapid growth in recent years of the double glazing and energy conservation industry which appears able to operate at good rates of profit), and with increased demand, unit costs may fall considerably. Considerable controversy now exists with regard to the role that nuclear power should play in the Scottish energy system. With Torness on stream, 60% of Scottish electricity is now nuclear sourced, making her one of the most nuclear oriented countries in the world. Nuclear energy produces very low greenhouse emissions during operational life, but this should not mask the very large power inputs (and thus pollutant emissions) in the material assembly, construction and decommissioning phases. For the UK as a whole, Dr. Barry Dale of the Energy Technology Support Unit has estimated that a trebling of UK reliance on nuclear power would lead to a reduction of only 11% in CO_2 emissions. Given recent evidence that both capital and running costs of nuclear power exceed those for conventional power, and taking into account other external costs of nuclear power, an expanding role for this energy source seems not to be cost effective. In view of these comments, I would suggest that an appropriate short and medium term strategy would concentrate resources on energy conservation (which has a very impressive performance record), increasing energy efficiency in both power generation and power consumption, and integrating some alternative renewable energy sources into the electricity supply system. All of these options are currently viable even on purely commercial criteria. If pricing were to reflect all social costs and benefits, these options could become highly profitable.

Government should provide a directing impetus too, by a gradual tightening of standards for new construction, pollutant standards and the like. In the medium to long term, there is a non-negligible probability that Scotland will be self governing; even in the absence of this outcome, there is still considerable scope for public agencies (and professional bodies) in Scotland to push standards in the suggested directions, and to exert pressure on national government to expedite tax or subsidy schemes that encourage emission reduction. Employment prospects in those industries linked into conventional energy should also be considered; in this respect, particular attention should be given to facilitating diversification schemes in Scotland's traditional energy businesses.

5. Global warming: a time of opportunity for Scotland

I remarked earlier that major structural change, and even times of apparent crisis, can generate opportunities for economic development if appropriate responses are made. Let us now consider what these opportunities may be. I am not arguing that a selfish or nationalistic stance is desirable, but simply that it is foolish to allow actions to be purely passive and reactive. Even in a world economy facing resource constraints, the competitive process will not disappear and we presumably would wish to maintain competitive strength.

The opportunities I describe largely arise from changing patterns of demand, both personal and industrial. These demand changes derive in turn from a number of factors:

(a) altered patterns of relative prices
(b) altered patterns of income and wealth distribution within and between nations
(c) changes in technology and in input-output relationships and coefficients
(d) policy-induced demand shifts
(e) shifts in consumer preferences.

It would be foolish to indulge in too much crystal ball gazing, but the gains to be made by those individuals who are best informed are clear, and it is the case that some well-informed judgements with respect to points (a) to (e) are feasible. I will concentrate on those which may be of most relevance to Scotland.

One can expect strongly rising demand in certain sectors for three distinct reasons:

1. Because we are already committed to some global warming whatever policies are adopted, reconstruction, relocation and readjustment work of various kinds will be required. These will probably include coastal defence systems, flood control, water and sewage infrastructural adaptation and new (relocated) construction activity. The Scottish construction industry is, thus, likely to be in a strong position in the early years of the next century, but will need to develop new technologies appropriate to these demands.

2. The patterns of demand and prices will change, reflecting cost minimising choices made by firms and changing consumer preferences. Relative prices of different goods and services can be expected to change for a number of reasons, including shifts in preferences, policy changes and changes in technology and relative scarcity induced by the prospect or outcome of global warming. Where prices rise as a result of cost increases (for example when pollution taxes are imposed upon outputs, or marginal costs rise for resource extraction), profit expectations do not in general rise (and indeed are likely to fall). But for many commodities, prices will rise as a result of demand increases, and in these cases firms can expect enhanced profits and should allocate additional resources into their production.

   Indeed, we already have ample evidence to show that consumer demands are changing, and that firms will need to respond to these changes if they are to maintain profitability. What is yet to be felt are major changes in demands for capital and intermediate goods. Candidate areas for major demand expansion in this respect include:

   -biotechnology research and applications
   -energy control and energy efficiency systems
   -business financial, planning and management consultancy services
   -emission control equipment and monitoring systems
   -vehicle engine design and construction
   -district space heating systems
   -waste-to-energy applications
   -high performance materials
   -energy storage schemes
   -semi-conductor applications

   When we take account of international demand, and the consequent export possibilities, the list may also include such activities as water resource development, desalination schemes, irrigation technology, crop research and development, biogas engine technology and soil stabilisation schemes. This lists are far from exhaustive and could easily be considerably extended.

3. Policy constraints

   Whatever individuals and firms choose to do, another overlay on this picture will reflect constraints imposed by policy. It is very likely that quantitative controls on the inputs and outputs of various goods and resources will be imposed by public bodies, both in the UK and elsewhere. Such constraints would further alter the structure of demand. Predicting policy responses is particularly hazardous at the best of times, but it is reasonable to presume that policy controls would tend to reinforce the demand changes just described.

It is clear from a perusal of this list of candidate sectors for expansion that the Scottish economy is in a strong position to take advantage of these opportunities. It already possesses production and/or research capacity in several of these activities, including pollution control (eg Babcock Engineering), desalination technologies (with a strong research base at Glasgow University), and in more general terms, strength in alternative energy research, and energy conservation and efficiency schemes.

The financial and business services sector is well established in the major Scottish cities, and we possess a strong base for consultancy services in the fields of planning, business management, engineering and technological innovation.

The interface between research in academic institutions and industrial innovation and application has improved dramatically in recent years. Most Scottish higher education institutions have established technical consultancy businesses, or forged links with private sector establishments, and several of

these activities have exhibited dramatic rates of growth.

A particular feature shared by many of the sectors is their heavy dependence on research, development and information, and the linkages of the activities to the science and engineering, and business management infrastructures. The Scottish economy has great strength, to some extent underexploited, in each of these areas. Many business and engineering graduates leave Scotland soon after qualification, in the absence of a sufficiently large local market for their skills; I am the suggesting that the demand side of these markets is likely to be considerably enlarged in the medium and longer term future. What needs to be high on the policy agenda is the encouragement of supply side capacity to respond to these demands.

The outlook is not entirely rosy however. Scotland is considerably over-supplied in terms of power at the moment, and this excess supply is expected to persist for some time. Taken in conjunction with the current low real prices of fossil fuels, there is little commercial incentive to adopt or develop cleaner energies. The prices of energy are essentially "wrong", being set at levels well below their true social marginal costs. Until tax and subsidy schemes push relative energy and resource prices closer to their true social costs, there will be little chance of private markets making some of the adjustments that are widely agreed to be desirable.

6. Conclusions

Industrial policy and environmental policy may have been seen as essentially unrelated in the past, but can no longer be treated as independent. Scottish entrepreneurial skill may be sufficient to identify the market opportunities described in earlier sections of this paper, but a more cautious approach would suggest the judicious use of public sector catalysts to expedite the capture of these opportunities. I would suggest that a number of steps should be pursued as soon as possible.

A. The Scottish Development Agency should establish an advisory and co-ordinating capacity to encourage and facilitate private sector capacity in each of the activity areas identified above. The precise ways in which this should be operationalised will be left for the reader to ponder.

B. There are several areas in which research and development should be considerably increased. These include bio-technology applications, advanced materials engineering for high stress environments, solar technology applications, pollution control and monitoring, energy storage schemes, and semi-conductor innovation.

C. Competitions, offering substantial pecuniary rewards, should be launched with the intention of encouraging innovations in these and other areas. The major Scottish banks may well be encouraged to consider financing such competitions, given the commercial returns they could expect from financing winning schemes. Bodies such as Scottish Enterprise could play an important role too in this regard.

In the longer term, it is imperative that relative prices adequately reflect social costs. All steps towards this goal should be taken at the earliest time possible.

What is clear is that while it would be dangerous to ignore warnings of impending environmental crisis, a more fruitful attitude is that which searches for commercial prospects that will arise. By harnessing these opportunities, we are most likely to develop the conditions for sustainable development.

Footnotes

1. The validity of this claim may not be immediately obvious, so a little explanation is warranted. Assume critical threshold levels of total greenhouse gas concentration exist, such that beyond these levels, further emissions of substantial quantities will cause substantial alterations in climate. Further assume that these climatic changes result in large costs in terms of flood damage, crop failure, and so on. If the world economy continues to emit pollutants, then a time will arrive at which thresholds such as these will be reached. The objective of policy is to prevent concentrations of pollutants passing these threshold levels, or at the very least to put forward in time the point at which the thresholds are hit.

A project today which reduces emissions may well have very limited current benefits, but in so far as it delays or avoids this threshold effect, will have large benefits in the future. Whether we, today, believe that it is worth incurring current costs to derive future benefits depends on our degree of inter generational concern. What is clear, though, is that if action is not taken now, it will be required on a much greater scale later, and we have good reason to believe that the unit costs of adjustment will be far higher the greater the scale of adjustment. This suggests that if policy makers wish to optimise policy over a longish horizon, gradual anticipatory action will be more cost effective than sudden adjustment.

Note also that this argument was couched in terms of threshold effects. However, the essence of this argument remains true even if there is a more proportional relationship between emission levels and damage.

2. Current best forecasts for Scottish climate changes and their consequences in the middle of the next century suggest the following. Mean temperatures will be about 3 degrees Celsius higher than now, growing areas will shift 300 feet upwards, and a wide variety of trees, shrubs and plants currently unsuited to Scottish climate will be supported in Scotland. Crop yields and vegetation growth rates in general will increase. Although some "losses" will probably occur, such a prospect is, in itself, far from unattractive. But two points should be stressed. First, such predictions are subject to massive uncertainty. Second, the future standard of living of Scots is dependent very strongly upon the ways in which climate changes occur elsewhere in the world. A parochial stance which looks forward to a superior future local climate is thus misplaced.

3. Scarcity is used here in the economic sense, not its common usage. That is, a resource is said to be scarce if its supply is finite, and demand (over all time periods) at zero price would exceed that supply. In this sense, virtually all resources, goods and services are scarce.

4. John Vidal, The Guardian, 26.1.90, quotes energy costs based on the 1987 Watts Committee on Energy. Land wind energy is estimated to be generated at 2.26 p KWh, compared with CEGB electricity from coal at 3.5 p KWh, and nuclear costs of not less than 6.3 p KWh. Wind energy is at present easily the cheapest alternative source of (large scale) energy production in the UK.

5. This possibility has a high likelihood. Newly industrialising countries will tend to develop in ways that are energy wasteful, and so the potential gains to be made by enhancing efficiency, for example, are correspondingly high.

References

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