Finding The Middle Ground:
The Use of Market Incentives to Protect the Environment

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1. Economic Incentives and the Environment

1.1 Decentralised decisions and prices

Because environmental resources—air, water, soil, ambience, and so on—are available at little or no cost, not surprisingly they are over-used. This means less clean air, clean water, uncontaminated soil, and fewer quiet environs than we should like. It follows that proper pricing will reduce the use of environmental resources by providing the correct incentives for firms, for organisations, and for households as they make their decentralised resource-use decisions. That is, since clean air and water and waste sites are not unlimited resources, they should not be available at no cost to the users. Rather, users should pay a price for the use of the resource, a price which reflects the relative scarcity of the clean air or water or waste sites, or the cost imposed on neighbours from noisy behaviour. Moreover, resource-use decisions are most efficiently and flexibly made by those closest to the technologies, in a decentralised fashion.

This proposal—user pays—requires the imposition of taxes, and is firmly in the context of a decentralised economy, in which decision-makers respond to relative prices in making their choices, and have the freedom and flexibility to determine how to behave. In the case of pollution, such a scheme leaves it to the factory managers to decide how best to deal with the additional cost their unaltered behaviour would impose on society. If the cost of altering their practices to reduce pollution is less than the cost of such pollution on society—as reflected by the level of the pollution tax—then they should alter their practices and produce less pollution, that is, use up clean air and water at a lower rate.

More fundamentally, however, the issue is one of altering the behaviour of firms, organisations, and individuals or households. For instance, if we wish to reduce the amount of fuel used on our roads, and hence reduce the amount of carbon dioxide produced as a product of combustion, there are four sorts of decisions we should like to affect:

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- ideally, the planners' initial decisions over land use and population density—one trade-off is more space per inhabitant against less use of energy, materials, and time in transport;
- the manufacturers' decisions of what range of vehicles of different fuel efficiencies to manufacture or import and offer for sale—one trade-off is safer, faster, less frugal vehicles against smaller, more frugal vehicles;
- the households' decisions of which vehicles to buy, so constraining their future fuel efficiencies—one trade-off is power and convenience against compactness and fuel-efficiency; and
- the households' continuing decisions about how many kilometres to drive, how heavily laden the vehicle is, how well-maintained the vehicle is, and hence how much fuel is used on an annual basis—one trade-off is better maintenance against higher fuel bills.

1.2 Mechanisms for changing behaviour

Market-based economic mechanisms, or *exchange* mechanisms—such as taxes and charges, subsidies, and tradeable permits—are only one possibility for altering the behaviour of individuals, firms, and other organisations. There are two other broad categories of mechanisms, call them "authority" and "persuasion" (Lindblom 1977). Figure 1 shows this categorisation. Any point on the triangle corresponds to particular proportions of the three mechanisms, depending on the distances from the three vertices. It is possible to plot instruments for control, or even societies, on the graph, depending on their mix of the three basic mechanisms.

Authority mechanisms are the traditional method of dealing with environmental issues by "command and control" regulation: the government sets legally enforced standards, together with penalties for transgressors, and a system of inspection has the power to require alteration in behaviour and can fine or institute proceedings against such damaging behaviour. This is the legal way of affecting interpersonal behaviour: laws against certain behaviour, with penalties preferably to deter, ultimately to punish.

Persuasion mechanisms include education, inculcation, and even indoctrination towards certain approved behaviours, or social norms, and against other "anti-social" behaviours. Although apparently benign, in the extreme these methods of social control can result in the terrors of a Cultural Revolution (Boulding 1978).

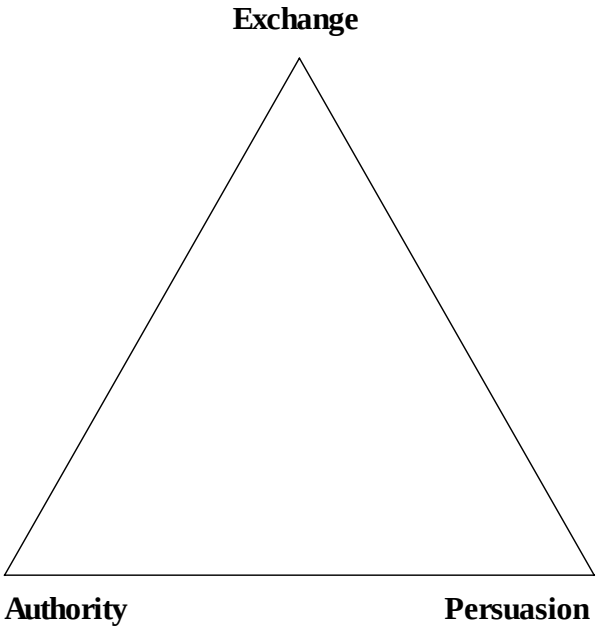

Figure 1: Three-Way Classification of Control Mechanisms

1.3 International comparisons

It may be possible to characterise countries or societies by the extent to which they lean towards exchange or market mechanisms, towards authority mechanisms, or towards persuasion mechanisms. In Australia, some might argue, we have relied to a large extent on the authority mechanisms of command-and-control, with a certain mistrust of the collectivism of persuasion (perhaps from our penal origins), and with only a marginal use of pricing mechanisms to augment the operations of the market. Some work has been done on the reason for our heavy reliance on authority and our neglect of the market mechanisms:

- it may be because of Australians' traditional concern for distributional fairness,
- it may be because of the lack of effective competition in Australian markets, with the possibilities for sellers—and to a lesser extent buyers—to take advantage of their market power to squeeze buyers (or sellers),
- it may be because of the traditional memories of the "dark satanic mills" of the early industrial revolution in England, a revolution driven by the market imperatives of accumulation and technical change.

At any event, the opening up of the Australian economy through the reforms of the early nineteen-eighties has changed our perceptions of ownership and control and the market mechanism, while economists have been arguing that it is better to make the market work with environmental objectives, rather than trying to ignore these pressures, or even working against them.

If the events of the past eighteen months in Eastern Europe tell us anything, it is that the incentives for innovation and invention and economic efficiency of the market-based "mixed economies" of the West have dominated those of the East: higher output per worker and lower environmental disruption per unit of output than the creaking economies of the East.

Granted, the market mechanism has resulted in growing environmental problems—even if proportionately much less than those of the East—but it is only through the higher productivity (output per employee-hour) of market-based economies that we can afford to protect the environment and continue to enjoy the standard of living to which we have become accustomed.

The global environmental impacts of the efforts of the Third World to emulate our successes in terms of output of goods and services will inevitably be large, even if the most efficient instruments—those based on the market mechanism—are successfully implemented in those countries. There is also an issue of the extent to which the industrialised countries should attempt to impose our environmental standards on the developing world. We discuss this below, together with the advantages of exchange instruments in achieving higher standards of living while keeping environmental impacts to a minimum: flexible, decentralised, efficient decisions.

1.4 Instruments for pollution control

The three broad mechanisms of the Figure can be used in the specific case of altering behaviour to reduce pollution. Arbitrary standards imposed on economic actors with punitive penalties for non-compliance is a case of the use of Authority to alter behaviour. (Specification of machinery or processes—"best practice"— is another case.) Such a course of action might be justified by the consequences if the standard were exceeded. Persuasion might be exemplified by exhortations from the government for individuals to behave responsibly by curbing their polluting behaviour. (In the longer term, the evolution of social norms against polluting behaviour is another case.) Examples of exchange mechanisms are discharge taxation, subsidies for discharge reduction, tradeable emission permits, and taxation of inputs, such as carbon taxes.

Following Bohm and Russell (1985), Appendix D of the Industry Commission Report (1991) compares command-and-control standards for

pollution regulation against exchange mechanisms, using the criteria of (*a*) dependability in attaining the target standard, (*b*) efficiency at attaining the target at least cost, (*c*) the information requirements necessary, (*d*) the ease of monitoring and enforcement, (*e*) the flexibility of the instrument, (*f*) the equity of distributional impacts, which is related to the political feasibility of the instrument, and (*g*) the extent to which there remains a continuing incentive beyond the target. Tradeable permits are both dependable and efficient, and depending on their government-determined lifetime they can be used flexibly, with the total number of units falling or rising as more recent scientific information comes to hand.

2. Rational Resource Allocation

2.1 Common-property environmental resources

The underlying philosophy of neo-classical economics is utilitarianism. Properly functioning markets mediate between willingness and ability to buy on the one hand and the cost of production on the other, as reflected in market prices. With a properly functioning market mechanism, the preferences of the consumers—for bread, for accommodation, for travel, for haircuts, for cellular telephones and electronic pagers—are reflected in the prices at which these final products and the intermediate products which are used in their production and the natural resources at the headwaters of the economic river are bought and sold.

There are many impediments to the smooth operation of such a mechanism—to some of which the Trade Practices Commission addresses itself—but the absence for markets for environmental goods and services is what we are discussing today. One characteristic shared by most environmental resources—and something that explains the lack of markets for environmental amenity—is that they are *common-property resources*, in which property rights are poorly, if at all, defined. The lack of property rights means that no-one has an incentive to manage the resource properly, and overuse is the consequence. This characteristic has been dubbed the "Tragedy of the Commons" (Hardin 1968), which led to literal overgrazing of the village commons in mediæval England, and to-day results in metaphorical over-grazing of the resources of clean air, clean seas and oceans, and the atmosphere.

Of course, clearly defined property rights are not *sufficient* for proper husbanding of environmental resources, as many examples demonstrate, such as soil erosion in many Australian paddocks. (Fisher 1981, p.85, provides an analytical explanation that if the discount rate is sufficiently high, the present value of complete harvesting of a renewable resource to extinction

today is greater than the present value of continual harvesting—which raises the issue of the appropriate discount rate.) But in the absence of property rights, without other incentives to encourage economising behaviour, overexploitation will invariably result.

One important common-property resource is the electromagnetic spectrum. In the absence of management of this by the government, it would soon become hopelessly crowded and congested. Internationally, such crowding is always a danger, and yet agreement among sovereign nations over the use of this scarce, common-property resource is possible and has been achieved. That should encourage us as we consider the possibility of global warming and the greenhouse effect.

As remarked above, the free availability of clean air, clean water, quiet ambiance, and other environmental amenities has led to overuse of these resources. For twenty years or more there has been concern at local effects of this: pollution, premature exhaustion of common-property resources, and so on, but recently—with the realisation of the effects of chlorofluorocarbons (CFCs) on the ozone layer and the possible effects of carbon dioxide and other "greenhouse" gases on the earth's temperature—there has been concern at global pollution.

2.2 Efficient levels of environmental use

Rational resource allocation occurs when at the margin the gain from using the resource is equal to the cost of using it. For ordinary goods with no spillovers, competitive market allocation results in this "efficient" outcome: the gain and the cost are borne by the private decision maker, but equal the social gain and cost, respectively. With common-property resources such as environmental resources, however, the gain from their use (to the polluting firm, for instance) is much less than the cost to society locally or globally. The absence of prices means that the cost is not reflected in the sacrifices necessary to use the environmental resource up. In consequence, the resource allocation is excessively tilted towards use of these "free" resources—so-called because despite their scarcity there is no price to be paid, even if their use imposes a cost on others now or in the future. At the margin, the gains from much environmental despoliation are less than the value society now places on environmental protection. We should reduce the levels of despoliation which are occurring from overuse of the environment.

Rational allocation would not in general correspond to zero use of the resources, rather it would correspond to a level of use at which social costs and benefits were balanced—where, ultimately, social costs and benefits reflect the preferences of people for trees and for paper products, for their own cars and for a stable climate, for Kakadu and for the products made from

mined materials, for clean water at Bondi beach and for affordable sewerage charges.

But, as the saying has it, "there's no such thing as a free lunch." The issue for the economist, in Wordsworth's phrase, is "nicely calculated less or more": the proper balance or trade-off between our desire for a healthy sustainable world and our desire for goods and services, the provision of which imposes pressures on the environment. What is the best trade-off between environmental amenity and goods and services, the production of which cost us environmentally?

3. Emission Taxes and Charges

As Mark Twain observed, there are only two certainties in life: death and taxes. We usually think of taxes as sources of revenue for the government—and this is their original purpose—but, in altering relative and effective prices, taxes also affect the decisions of individuals. A classic example is presented by the mediæval window tax, which levied an amount from each household in proportion to the area of windows in the house. The result is readily imagined: soon houses were being built with smaller windows, and some existing windows were being boarded up by early tax avoiders—no doubt, at some cost to the health of those living within.

By reducing the gap between the private cost to the users of the resource and the public cost to society of the resource's use, emission taxes can provide an incentive for economising on use of the environmental resource by its users, while preserving their freedom to use and pay up to the point where developing and using substitutes becomes cheaper.

The use of such taxes does not, of course, obviate the need for monitoring environmental use, and possible prosecution for cheaters, but by utilising the market mechanism it provides the correct incentives elsewhere in the market, for instance, downstream, for those who would buy the products sold by the firms using and paying for the environmental resources.

3.1 The correct level of environmental taxes

But as well as a further task for the Taxation Commissioner, the question arises as to the correct level at which the taxes should be set. Market exchange determines price and quantity simultaneously. In the absence of a market, the government can choose price or quantity individually, but attempting to choose both will almost always fail.

As we see below, when we consider the example of "carbon taxes" to ameliorate the greenhouse effect, specifically from road transport in Australia, there can be large variations in estimates of the correct level, since there are often large variations in the estimates of the sensitivity of

consumers' demand for goods and services in the face of higher prices. If there is a need to limit aggregate emissions below a threshold—as, say, with the Toronto target for reduction in carbon dioxide emissions—then a simpler method may be to provide a system of "rights to emit", or emission permits.

In the case of *emission charges*, such as a carbon tax, the government sets the tax charges—as so many dollars per unit of contained carbon—and the market determines the quantity. In the case of tradeable *emission permits* (described below, and in Dales 1968), the government determines the quantity in aggregate, and the market determines the price per unit of permitted emissions (Hahn 1989).

If emissions impose a high social cost which must be reflected in a relatively high tax on, say, the use of such products as CFCs (although international agreements have determined to ban rather than to tax CFCs, such is their virulence on the atmospheric ozone), and if there are few substitutes for the taxed good, then the tax will be regressive and will generate substantial revenue. The politics of implementation would suggest that such taxes be phased in and that there be lump-sum rebates to low-income households from the revenue. In the limit, such taxes could be revenue-neutral, by returning all their revenue, after altering relative prices, of course.

Emission taxes and charges have been used for water pollution in several European countries: France, Italy, Germany, the Netherlands (Hahn 1989), and in Japan. Sweden has used emission charges to induce people to equip cars with control devices (Opschoor and Vos 1989). The Dutch have charged the highest fees. There is evidence that at low levels, sources regard charges merely as revenue-raising devices, and that it requires higher charges to induce reductions in use. The Dutch experience reveals evidence of such reductions (Tietenberg 1990*a*).

4. Markets for Tradeable Permits

The traditional command-and-control, authoritarian approach to thresholds of pollutants has been to set legal standards and to enforce transgressions with high penalties.

Four recent American examples have been:

- the 55 mph blanket speed limit imposed upon U.S. roads after the first oil crisis in 1974, in order to reduce oil consumption, and so to reduce dependence on oil imports;
- in some states such as California, the requirement for the existing fleet to be retrofitted with emission-control equipment;

- the standards for new-car fuel efficiency that were imposed on automobile manufacturers soon after, in order to encourage the manufacture of cars that were more fuel-efficient, so that the average fuel efficiency of American cars would rise, as the efficient new vehicles entered the fleet; and
- the introduction of unleaded gasoline, made mandatory for new vehicles.

The speed limit imposed some inconvenience on individual motorists, on bus lines, and on trucking companies; incidentally, as I can attest to, it provided local police with windfalls in on-the-spot speeding fines. But traffic speeds did fall, if not always to below the new limit.

The emission controls might have reduced emissions, but there are no checks on actual vehicle emissions, which provides an incentive to cheat by, for instance, disconnecting or otherwise incapacitating the system, resulting in a noticeable improvement in vehicle performance.

The fuel-efficiency standards also worked, since the average fuel efficiency of new cars sold increased. But at the same time (the late 'seventies) the price of gasoline was also rising, so the buyers' preferences might have been affected by that. When the oil price faltered and began to fall, so too did Americans' appetites for smaller cars, despite the continuing standards. Unleaded gasoline reduced the average level of air-borne lead, a proven health hazard to young children, at some cost to vehicle performance.

But such curtailment of activities—speeding, installing emission-control equipment, using less fuel-efficient cars, using cheaper leaded gasoline—imposes costs on society, even if they are not readily quantified. These costs would be reflected in the reduction of consumer's surplus such restrictions result in (Hahn 1989, Tietenberg 1990*a*, Hanley et al. 1990).

As mentioned above, rather than setting the price and letting the market determine the quantity, as people react to higher prices by curtailing their purchases, *tradeable emission permits* allow the government to set the quantity of emissions and let the market determine the value of these rights. That is, such permits have the advantage of standards in that quantities are controlled, and they have the advantages of markets in allowing trading between those who find it cheaper to buy additional permits to emit than to abate their emissions, and those who find it cheaper to reduce their emissions and realise the value of their now-unused permits on the market. This is efficient allocation.

This means that emitting sources can find the cheapest means of satisfying their (legal) requirements: abatement of their own emissions, or vicarious abatement on the part of other firms. Cost-minimising firms minimise the sum of (*a*) the costs of acquiring further legal rights to emit (the

permits), and (*b*) the costs of abating their emissions. In so doing, they will choose the most cost-effective outcome perhaps through investing in new technology, which is encouraged by lower interest rates, ceteris paribus.

Tradeable emission permits is a system in which the best informed decision-makers—who are not necessarily the Sir Humphreys of government—are encouraged to use their knowledge and experience to satisfy the quotas of emissions allowed by the permits.

Emission permits will only work perfectly where a reasonably efficient market can occur. The system will not work well (efficiently) when the cost of finding buyers and sellers is high, or when there is a market leader which might use its market power to engage in strategic squeezing of smaller emitting firms. (The question of how well such taxes will work in this second-best world is difficult to conclude, ex ante.)

Because of the need to monitor emissions, permits will work well with a small number of stationary sources of emissions, for example, electricity plants. They will not work well with a large number of moving sources, such as motor vehicles. Nor will permits work well when the local concentration of pollutants is an issue, such as with particulates. There remains the possibility, however, of controlling the manufacture of polluting machinery through the use of tradeable emissions permits: a recent proposal in the USA would have allowed car manufacturers to vary the per-mile emissions designed into new vehicles, so long as they had bought from other manufacturers sufficient permits to cover the higher emissions. The choice was theirs to make, in the context of a limit on total designed emissions from new vehicles overall.

Emission permits are, in effect, property rights over environmental resources. They entitle the holder to use up these resources—at least temporarily—by producing emissions, up to the limit specified by the permit. As with all exchange instruments discussed, we focus on the means rather than the ends. In an attempt to allay fears that I am proposing wholesale abrogation of its environmental responsibilities on the part of government, I emphasise that the markets for tradeable permits are artificial, depending on the government for their creation and maintenance. The government must monitor the environment beforehand, set the tax levels or total quantities of permits per period (a year or more, usually), monitor performance, and enforce compliance. Exchange instruments are not a panacea, but further means of managing the environment.

4.1 Allocation of permits

Permits can be allocated in various ways to begin with:

- they can be auctioned (as was tried with some radio licences recently),
- they can be distributed through a lottery (as happens for mining rights in Wyoming), or
- they can be "grandfathered" in, whereby the sources of emissions create emission rights as surplus emission reductions over a predetermined level of emissions.

In the absence of high transaction costs or lack of competition, the initial pattern of distribution is irrelevant for the final pattern of permits after trading has occurred, but there may be distributional effects.

If there are large revenues raised from the permits, or from taxes, even though these revenues are simply transfer payments, they can impose a significant burden on individual enterprises. For this reason, it appears to be important that the revenue-raising be legitimated in the eyes of the emission sources (Hahn 1989). Hahn found that the main use of government revenues raised from emission sources was to pay for government abatement. This "recycling" in the industry appears to legitimate the charges.

Emission permits have been used in the USA to reduce lead levels in gasoline by a system of permits tradeable among refineries (Hahn 1989, Tietenberg 1990*a*). They have also been used to improve air quality under the Clean Air Act in the USA (Hahn 1990), although there were objections to a thorough implementation (Hanley et al. 1990). They have also been used as transferable catch quotas in New Zealand fisheries (Anderson 1989). As the Industry Commission (1991) reports, tradeable permits have recently been introduced in Australia for CFCs, although "Australian consumption of the scheduled substances is still less than the volume permitted by quota" (1991: p.D14).

5. Impact on Business Competitiveness

With no change in preferences between manufactured goods and environmental amenity, it is straightforward to demonstrate that technical change—the ability to produce more goods for the same cost in terms of environmental amenity—will result in a higher trade-off between the two, increasing the value of environmental amenity vis-à-vis manufactured goods (Fisher 1981, p.134).

As an industrialised democracy, Australia has a strong and growing demand for environmental amenity, but we also depend for much of our export income on the products of extractive industries—mining, agriculture, and forestry. Hence, there is a danger that in order to maintain our high environmental standards we export jobs and profits and pollution to countries

with lower environmental standards than ours. That is, we pay a price for a cleaner, more pristine environment in terms of employment, profits, and affordability of manufactured goods.

Cabinet has recently been considering whether to adopt the Toronto target for carbon dioxide emissions, of a 20% cut from the 1988 levels by the year 2005. At the same time, there has been an apparent hardening to demands from conservationists for further conservation measures in the South-East forests. Is Senator Button correct in his statement that Australia would be hurt by unilateral adoption of the Toronto targets, which are anyway only interim? The atmosphere is a global resource. Except perhaps for the USA no one country's actions—including Australia's—will have more than a marginal effect on atmospheric concentrations of greenhouse gases. The Industry Commission's Report (1991) confirms this.

Another manifestation of the Tragedy of the Commons is the Prisoner's Dilemma, a situation in which two parties, acting together, can do very well, but in which there is a strong incentive to cheat on the other party and do even better. If both cheat, both do badly. This is an all-too-common dilemma. It describes the incentives facing members of a cartel with imperfect monitoring: if one increases his output (of oil, say), then he will increase his revenues; but if all do it, then the price of oil will plummet, and revenues will fall, despite—in fact, because of—the higher levels of output in aggregate.

Moving first to adopt higher standards, if it imposes higher costs on domestic industry, is like being the good guy in the Prisoner's Dilemma. You're liable to do badly as others take advantage of your public spiritedness. This is not to argue against efforts to reach international agreements on common measures to fight environmental problems at a global scale, but it is an argument against unilateral, romantic gestures, which could prove very costly. Call this *First Mover Disadvantage.*

The oceans, and the Law of the Sea convention, provide a lesson in the methods of attaining international agreement—it took several years. One reason is the distributional issue facing conservationists and others who would attempt to reduce the rate at which rainforest is being cut down: the Third World countries whose rainforest it is are not prepared to forgo what to them is a potential source of hard currency with some compensation from those in the rich nations who would restrain them. A further reason is that one's preferences change when one is starving. That is, poor countries might be prepared to accept lower levels of some sorts of local environmental amenity in order to attract industry and jobs. This is a case of richer nations exporting pollution (and jobs) to poorer ones.

5.1 Australia and the cost of abating greenhouse emissions

The study I and others performed for CRA Ltd. (Marks et al. 1991) suggested that it was possible to attain the Toronto target for reductions in carbon dioxide emissions by 2005 of 20% below 1988 emission levels, but that for just the two sectors of electricity generation and road transport—ignoring such generators as land degradation and animal husbandry—there would be a significant cost in terms of growth forgone. Moreover, as the world's largest coal exporter Australia would be hurt by a fall in world demand for coal.

Over the seventeen-year period from 1988 to 2005 we estimated that this would cost $20 billion, discounting at 10% p.a., and the effect would continue beyond 2005. Further, for every 1% p.a. fall in the world price of coal, as other countries reduced their demand for coal (which is a relatively high-carbon energy source), the effect on Australia in terms of growth forgone would be $3.3 billion over that same period. This cost is beyond our control, but it highlights Australia's need to reduce further burdens on the economy, especially if our trading rivals are not so handicapped. The Industry Commission (1991) analyses these issues at greater length.

6. Case Study

We cite several studies (Hahn 1989, Niland 1991, Opschoor and Vos 1989, Pearce et al. 1989, Stavins 1989, and Tietenberg 1990*a*,*b*) which discuss several case studies. Here we focus on one.

The greenhouse effect mentioned above is the suggested warming of the earth's atmosphere accompanying the increased concentration of gases which prevent or retard the radiation of heat from the atmosphere into space. Although there remains scientific uncertainty over the extent of global warming, the causal relationship between such warming and the increased concentration of greenhouse gases—carbon dioxide (the most important), methane, CFCs—in the atmosphere (Channel Four Television 1990), the reduction of emission of such gases is clearly on the political agenda. Much of the emissions comes from burning carbon-based fuels—coal, oil, and natural gas, from most carbon-intensive to least. Consequently, there are five ways of reducing carbon dioxide emissions:

- capturing the carbon dioxide from the exhaust fumes;
- using lower-carbon fuels;
- using more fuel-efficient engines and processes;
- reducing the levels of energy-using activity; and (ultimately)

- reducing our rate of population growth.

As part of the CRA study, we first attempted to forecast what the level of carbon dioxide emissions will be in 2005 in the absence of any special measures to reduce them. We projected that they would grow 43.6% above 1988 levels, which makes the task of attaining the Toronto target of 20% below 1988 levels non-trivial. Although we examined electricity generation as well as road transport, I want to focus on the latter sector here.

A tax alone, with no forced improvement of new-car fuel efficiency, would have to grow at a minimum of 5.7% p.a., compounding over the seventeen years 1988–2005, in order to reduce fuel consumption sufficiently that the Toronto target for carbon dioxide emissions from Australian road transport would be met. Mandated fuel-efficiency improvements to new vehicles which would more than double fuel efficiency, but at a cost of an increased capital cost of 25%, would not be sufficient, merely reducing the rate of growth of emissions, but not resulting in their reduction.[1]

We finally considered a combination of mandated fuel-efficiency improvements to new vehicles, together with fuel taxes to further reduce fuel use. The fuel tax in this case was a minimum of 3.7% p.a. (with a price elasticity of 0.6), which would compound to 188% over the seventeen years.

A more recent study (Ironfield and Cosgrove 1990) has performed a sensitivity analysis on necessary carbon taxes to attain Toronto, with different price elasticities and different demand forecasts. The required carbon tax on automobile gasoline ranges from $1.09 per litre with a high elasticity and a low growth rate, to $14.00 per litre with a low elasticity and a high growth rate. The tax is especially sensitive to the price elasticity of demand. Their most likely tax figure is around $2 per litre.

Both studies considered the transport sector in isolation. But attaining Toronto in this sector may be much more expensive than attaining, and exceeding, Toronto in other sectors. This is because of the patterns of land use, the lack of attractive substitutes for the private car, and the lack as yet of attractive substitutes for petroleum-based fuels. Were such fuel taxes implemented, then the incentives for the development of such substitutes

1. A recent study of automobile fuel efficiency suggests that the figure of 25% of capital cost which we used in the CRA study is excessive and that a similar increase in fuel efficiency could be achieved at a much lower cost (Difiglio et al. 1990). But even if the fuel efficiency gains could be achieved at an unlikely zero increase in the cost of a new vehicle, the cost to the economy over the seventeen years from 1988 to 2005 would still be high because of the fuel taxes still necessary, with the *implementation cost* still to be counted. This cost is often overlooked or wished away, as in Deni Greene (1991, p.25).

would be much greater.

This highlights the effectiveness of market-based incentives over command-and-control instruments: rather than mandating a blanket 20% reduction from 1988 in the emissions from each sector, it will be cheaper to seek to achieve a 20% reduction in total, and let those sectors for which it is relatively easy to cut emissions bear more of the burden than those sectors for which it is expensive. The same goes for States and for countries. Consider electricity generation: since Tasmania uses virtually no coal-based fuels in its grid, requiring each state including Tasmania to cut its carbon-dioxide emissions from electricity generation by 20% is virtually impossible for Tasmania, but much easier for Victoria with its brown-coal-based generators. (Victoria could import electricity from New South Wales or Tasmania, or could use electricity more efficiently or generate it from other, less polluting, sources.)

The Industry Commission (1991) makes the point that since Australia has a relatively high per-capita production of carbon dioxide as a consequence of our wealth of fossil fuels, especially coal, a uniform reduction target across nations will be less costly for us to achieve than for nations, such as Japan, which are already less energy-intensive (energy per dollar of net domestic product) and less carbon-dioxide-intensive (units of CO_2 per dollar of net domestic product).

7. Future Use of Market Incentives to Attain Environmental Objectives

The issue of implementation is still a stumbling block. Rising populist sentiment could paint emission charges and permits as "selling the environment to the highest bidder" or "licences to poison the planet.", as Hahn (1989, p.111) discusses. Moreover, the generation of large revenues from taxes or from auctions of permits will highlight the distributional issues. Revenue-neutral, lump-sum rebates provide a safety net for badly affected households.

But the issue is how best to use market-based instruments, rather than whether to use them. Emissions taxes provide the correct incentives to decision-makers, and allow the market to determine the quantities. Tradeable emissions permits control the quantities, but allow the value of abatement at the margin to be market-determined. If this is difficult for decentralised decision-makers, such as individual motorists, then it might be possible to create tradeable permits for the manufacturers of polluting equipments, allowing, for instance, car manufacturers to make vehicles which could only produce an average of so much pollution per vehicle-km, but allowing trade in these "rights" to allow flexibility while providing incentives

for the manufacturers to cut pollution levels at minimum cost for the industry and hence for consumers and society. Tradeable emissions permits provide additional flexibility by separating the issue of who will pay for the controls from the issue of who will install them.

International agreements for emissions control provide the opportunity to use market-based instruments—emission permits, in particular—across frontiers, by developing a world market, to reduce the cost of compliance to the world economy, and hence allow greater reimbursements to be paid the poorest. So long as the allocation of permits—and hence the endowment of valuable instruments—is regarded as fair, an international market remains an exciting possibility, which is further explored in the Report of the Industry Commission (1991).

Appendix

> An economist and an engineer were walking down the street. "Look," said the engineer, "there's a $10 bill on the footpath." "Nonsense," replied the economist. "If there'd been a $10 bill on the footpath, someone would have picked it up already."

Recent studies of the feasibility and costs of reducing carbon dioxide emissions by reducing the combustion of carbon-based fossil fuels have not been able to agree even on a rough estimate of the costs. Several Australian studies, for instance, have considered the costs of attaining the so-called Toronto target. Such studies can be classified into two very different modelling approaches, what Darmstadter (1991) has called "bottom-up" and "top-down". "Top-down" studies, such as Marks et al. (1991), have found relatively high costs accompanying emission reduction. "Top-down" modelling uses aggregate historical measurements of past market responses in order to estimate the changes in incentives necessary to induce the desired alterations of behaviour. "Bottom-up" studies conclude that using state-of-the-art energy-saving technology it is possible to reduce both energy use and cost at the same time; that is, they derive a supply curve for energy savings that is negative for low-to-medium energy savings. These patterns are found across studies performed for other countries as well. As Darmstadter points out, the two approaches need not be inconsistent: the emphasis on energy efficiency of the "bottom-up" emaphasises one important factor, which is also incorporated in any analysis that considers the effects of price, income, and technological developments on both the energy demand and supply sides.

Saddler (1990) describes the "bottom-up" approach in four steps: first, on the basis of "cost and availability maturity" to determine the technologies to be deployed, where he argues that annualised cost is the most appropriate cost criterion. Second, to derive the extent of fossil-fuel-derived primary energy used in supplying the energy services where each technology is relevant. He argues that from these two steps it is possible to derive the supply curve mentioned above.

Saddler's third step is to determine a "maximum possible reduction," which will be less than the theoretical maximum reduction possible if all durable energy-using equipment were replaced overnight, as it were, because of the economic life left in existing equipment. His fourth step is determination of a "maximum feasible rate of reduction" of fossil-fuel use, which in turn will be less than the maximum possible, because of the "realistic responses of actual decision makers." Saddler believes that this is the most complex step of the analysis, although whether it is the analysis which is complex or the behavioural responses being analysed is not not clear. I agree with him when he states that these responses are susceptible to explicit influence through policy changes.

Saddler illustrates the first three steps of the analysis by an examination of moves away from use of fossil fuels towards a sustainable (renewable) economy in Australia. Using "levelised long-run marginal cost" as an appropriate basis for choosing between efficiency and new supply alternatives, he asserts that economically optimal technology (which is also energy-efficient) would spread "rapidly" through the economy. Using "year-by-year" marginal cost would reduce the attractiveness of new technology vis-à-vis existing plant, and so reduce the rate of diffusion of the new, more-energy-efficient technology through the economy. In Saddler's view this would be less than socially optimal.

At this point, Saddler does not continue with examination the fourth step: how to "initiate least-cost energy planning". Instead, he attacks a passage from Marks et al. (1989), referring to opportunities for more efficient use of energy in the manufacturing and commercial sectors:

> The economist is suspicious of claims that there are profitable opportunities still waiting to be taken advantage of. The suspicion is greater in cases when firms in competitive markets are the economic actors claimed to be ignoring unappropriated rents, [and perhaps less in cases when knowledge of possibilities is costly to acquire and when potential savings are a small proportion of expenditures or surpluses. The cost of information provides a rationale for government energy-labelling regulations for household whitegoods]. But if we accept that there still exist opportunities for energy consumers to save money and energy in the medium-to-long term, we are faced with the question of how

> to induce these consumers to take the actions [that will benefit not only the global population as a whole (through reductions inter alia in carbon dioxide associated with energy generation and use), but also themselves (through lower energy bills in the medium run)]. The economist believes that higher relative energy prices would be sufficient: [higher prices increase the potential returns, and furthermore provide the government, if higher taxes are the impetus for higher prices, with additional revenue to pay for other methods of inducement, such as publicity campaigns, provision of additional information, and perhaps even subsidising energy-saving investments, although such subsidies should be unnecessary]. — Marks et al. (1989: pp.58–59), [omitted material in square brackets]

Saddler lists eight factors in firms' decisions not to choose "the lowest economic cost option when making decisions about energy use". When we consider this list in detail, it becomes clear that, despite his denials, many of Saddler's factors point to costs that the firm faces in changing its decision-making behaviour. Cost-related factors include: the use of rules-of-thumb, little scrutiny of small-cost items, lack of knowledge of alternatives (as we referred to above), preferences for known and familiar equipment and suppliers, and unavailability. All of these factors can be thought of as economically rational: the costs of altering the behaviour are greater than the expected gains. (Market distortions may underlie the remaining three factors of: discount rates for consumers higher than those for producers, constraints on borrowing in the capital markets resulting in a higher shadow price of capital, and market prices for conventional sources which may not reflect the full social costs of their use.)

Saddler understands this point implicitly, by his mention of commercial energy service companies, which apparently show organisations how to reduce their energy usage for a fee. The problem remains of how—and at what cost—to induce the changes that would lead to Saddler's fourth step, the maximum feasible displacement of fossil fuels.

Saddler has no answer, but instead is reduced to the following comment on our proposal that price incentives be used (Marks et al. 1991): *"It is, in any case, fundamentally irrational to propose even higher prices to achieve an end which should be attractive at current prices, and is clearly not being attained for reasons other than the level of prices"* (p.206). Why, he does not explain. Nor has he apparently realised that we are not saying higher prices are necessary, merely sufficient.

The epigraph at the beginning of the Appendix is meant to emphasise the faith put by economists in the rent-seeking behaviour of actors in the market, and similarly the fact that, none the less, some actors will be fortunate, and capture above-average rents. Indeed, there is an element of paradox here: in order for competitive behaviour in the market to bid rents away, it is necessary for actors to compete for rents, despite the fact that on average all rents will disappear. The paradox is that if all actors believed that none could do better than average, none would try, and the market would be inefficient. It is only through rent-seeking that rents are bid away.

Let us assume that the economist in the epigraph is wrong and that there are $10 bills lying about waiting to be captured—this, after all, is what Saddler is claiming. How do we induce people to avail themselves of these rents if they are not already doing so? One way is to increase the opportunity cost of not doing so by, for instance, increasing the denomination of the bills. One cent may not be enough to stoop for, but $20 is another story. This is what we are suggesting with higher energy prices. It is not the only way: mandated changes may also work, but as the ORANI study shows (Marks et al. 1991), the costs of mandated changes are higher than the costs from higher taxes on fuels.

Saddler's disappointing rhetoric is echoed in a study by Deni Greene and Gary Gavin (Deni Greene Consulting Services 1991) comparing seven "bottom-up" studies of Australian greenhouse gas emissions and one "top-down" study, Marks et al. (1991). Skirting the gratuitous insult in the forward by the chairman (sic) of the Renewable Energy Authority Victoria, we turn to page 25:

> There is no doubt that it will be both difficult and costly to achieve the energy efficiency potential described in these studies. But the difficulties and costs are not economic in nature, but rather institutional. The difficulties will be in such things as setting in place standards for the energy technologies, the costs will be to such things as government, utility and manufacturing lethargy and inertia. This is not the same thing as economic cost.

Wrong, Ms Greene and associates. This assertion betrays a profound lack of understanding of the concept of cost, especially the costs associated with changing the behaviour of people, households, firms, and organisations. Saddler at least evidences an understanding of costs, even if his argument descends to invective and non-sequitors.

A final comment. There is growing skepticism at the urgency demanded by some environmentalist groups to restructure the economies of industrialised countries to reduce greenhouse gas emissions, given the evident uncertainties associated with the possible link between the accepted increase in carbon-dioxide concentrations, fossil-fuel combustion, the enhanced greenhouse effect, and global atmospheric temperatures. Manne and Richels (1991) present a model of "optimal hedging" which in deciding whether it is preferable to act and then learn (as is being urged) or learn before acting with some hedging. They use a decision-analysis framework which is eminently suited for analysis for any problems—including environmental problems—in which uncertainty—whether good news or bad news—will be resolved in the future, but in which waiting for this resolution may impose costs.

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