The economic impacts of uniform emission abatement

Brian S. Fisher and Stephen Brown
ABARE

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The purpose in this paper is to contribute to international climate change policy development by analysing the effects of adopting uniform or flat rate emission reduction regimes, under which countries are required to reduce their emissions to a level based on a uniform historical period.

The assessment encompasses the production, expenditure and trade impacts of uniform emission abatement policies on developed and developing economies in the period 2000–20.

Introduction

Widespread concerns about the potential risks of global warming motivated over 150 countries to become Parties to the United Nations Framework Convention on Climate Change. The Convention came into force in March 1994 with the aim of stabilising the atmospheric concentration of greenhouse gases at a level that would prevent 'dangerous human interference with the climate system' (United Nations 1992).

A fundamental result of the Berlin Mandate, agreed at the first Conference of the Parties to the Framework Convention in 1995, was the commencement of negotiations to establish greenhouse gas emission reduction objectives and policies for Annex I countries for the period beyond 2000. The deadline for an agreement on these objectives and policies is the third Conference of the Parties to the Convention in Kyoto, Japan, in December 1997. However, the nature of any possible outcome from Kyoto remains highly unclear as many countries are yet to provide the details of their proposals for targets and timetables for meeting those targets.

The assessment in this paper encompasses the production, expenditure and trade impacts of uniform emission abatement policies on developed and developing economies in the period 2000–20. No attempt is made in this paper to address the broader issue of assessing the overall costs of climate change itself compared with the costs of mitigation and adaptation. This subject is covered in the 'environmental impact assessment' literature (see, for example, Weyant 1994; Weyant et al. 1995; Reilly 1997). Also, only policies to abate carbon dioxide from fossil fuel combustion are considered in this paper. At this stage, data constraints prevent detailed analysis of policies affecting emissions of carbon dioxide from nonfossil fuel sources, other greenhouse gases, and greenhouse gas sinks.

The analysis presented in this report is based on applications of the MEGABARE model of the world economy (ABARE 1996). MEGABARE is a multicommodity, multiregion, dynamic, computable general equilibrium model designed to conduct research on issues facing the global economy, including the impacts of climate change policy (see, for example, ABARE and DFAT 1995; Brown, Feng, Kennedy and Fisher 1997). The model documentation, together with some working papers that illustrate recent model developments, can be found on ABARE's web site at www.abare.gov.au.

Global impacts of uniform emission reductions

A uniform targets approach to achieving emission reductions requires each Annex I country to reduce its emissions to levels based on a uniform base period such as 1990. This contrasts with a differentiated targets approach under which countries' individual economic and trade circumstances would be taken into account when their quantitative emission limitation and reduction objectives (QELROs) are set.

For illustrative purposes two alternative uniform emission abatement scenarios have been selected for analysis of their economic impacts:

- ***less stringent scenario:*** Annex I countries reduce their carbon dioxide emissions from fossil fuel combustion to 1990 levels by 2010 and further reduce emissions to 10 per cent below 1990 levels by 2020; and

- ***more stringent scenario:*** Annex I countries stabilise their carbon dioxide emissions from fossil fuel combustion at 15 per cent below 1990 levels by 2010 and hold emissions at those levels in the period to 2020.

Developing countries are not required to restrict their emissions growth in either scenario. This assumption is based on the requirement that the outcome of the Berlin Mandate negotiations will not require developing countries to take additional measures to reduce their emissions at this stage.

It is assumed that in achieving the emission reductions, governments adopt policy instruments that impose the smallest possible cost on their economies. A discussion of efficient approaches to reducing carbon dioxide emissions within a country is presented in chapter 11 of the Intergovernmental Panel on Climate Change's Second Assessment Report of Working Group III (IPCC 1995). If, in practice, least cost approaches are not adopted, then economic costs to a given Annex I region would be higher than those reported in this study.

In MEGABARE, least cost modelling of emission abatement involves imposing a tax on emissions of carbon dioxide in each period for which emission restrictions apply. The tax raises the costs associated with carbon dioxide emission intensive activities and encourages a shift of resources into less emission intensive activities, thereby reducing emissions.

Revenue from the tax is assumed to be returned to the economy in a lump sum fashion. In practice, changing the way in which revenue is returned to the economy can alter estimates of the implications of emission abatement. For example, some analysts have shown that using the revenue from a carbon tax to reduce government budget deficits or to replace highly inefficient taxes can confer some benefits on an economy (see, for example, McDougall and Dixon 1996).

Critics of such conclusions, including de Mooij (1996), point out that estimates of such benefits are highly sensitive to the type of models used for the analysis and the underlying assumptions. Further, the changes in income distribution implied by the shift in revenue base can render the reform of highly inefficient taxes using environmentally based taxes politically infeasible. In addition, such alternative approaches to the treatment of carbon

tax revenue do not permit the impacts of emission abatement to be separated from the impacts of taxation or budgetary reforms and they can provide a distorted picture of the impacts of emission abatement on economies.

A carbon tax is representative of the broad class of economic instruments that could be used by governments to reduce emissions, including nationally based tradable emission quota schemes. In the context of the MEGABARE simulations the carbon tax associated with achieving a given level of emission abatement can also be interpreted as the unit price of nationally traded emission quotas (Hinchy, Thorpe and Fisher 1993). In more general terms the carbon tax can be interpreted as the marginal cost to the economy associated with any least cost policy or set of policies designed to achieve a given level of emission abatement.

Impacts of policies on economies

The assumed emission reductions are estimated to impose losses in real gross national expenditure (GNE) on Annex I and non-Annex I regions as a whole (table 1). Global losses in GNE (and gross domestic product) at 2020 relative to the reference case are projected to increase from 0.8 per cent of GNE under the less stringent emissions reduction target to 1.1 per cent under the more stringent emission reduction objective.

The key source of economic loss in Annex I countries is an increase in industrial production costs and consumer prices as assumed emission restrictions force producers and consumers in Annex I countries to move away from carbon intensive fossil fuel use into more costly alternatives. The increased costs to industry tend to dampen economic activity. The resulting decline in demand for labour and capital reduces real returns to capital and labour (defined as the gains in output associated with adding an extra unit of capital and labour, respectively, to the economy), in turn, leading to reduced income and economic losses.

Table 1: **Change in GNE at 2020 relative to the reference case [a] due to emission reductions in Annex I regions**

	Less stringent scenario	More stringent scenario
	%	%
Annex I	–1.0	–1.5
Non-Annex I	–0.5	–0.2
Global	–0.8	–1.1

a The reference case is the projected outcome for economies included in the model in the case where no new emission mitigation policies are adopted. For details of the underlying assumptions for the reference case, see Brown et al. (1997, pp. 20–7).
Source: MEGABARE projections.

The impacts of Annex I policies on international trade can be significant for both Annex I and non-Annex I economies. For example, both Annex I and non-Annex I fossil fuel exporters can be expected to experience a decline in demand and prices for their fossil fuel exports. Also, Annex I countries with significant exports of fossil fuel intensive products (such as iron and steel, or aluminium in the case of Australia) could face a reduction in export demand as these industries begin to relocate to developing countries to take advantage of increased price competitiveness. While, on average, Annex I exporters of fossil fuel intensive products lose competitiveness, non-Annex I exporters of these products experience gains in competitiveness, leading to carbon leakage and contributing positively to GNE changes in non-Annex I countries.

The trade related impacts of Annex I emission abatement on a country will depend on two factors. The first factor is the extent to which a country is able to purchase more imports from its national income. A decline in a country's international purchasing power from national income will contribute to a trade related loss in GNE. The second factor affecting trade impacts experienced by a country is the change in its ability to buy imports with a unit of exports, as measured by its terms of trade. A decline in a country's terms of trade represents a devaluation of its export returns, contributing to a trade related loss in GNE.

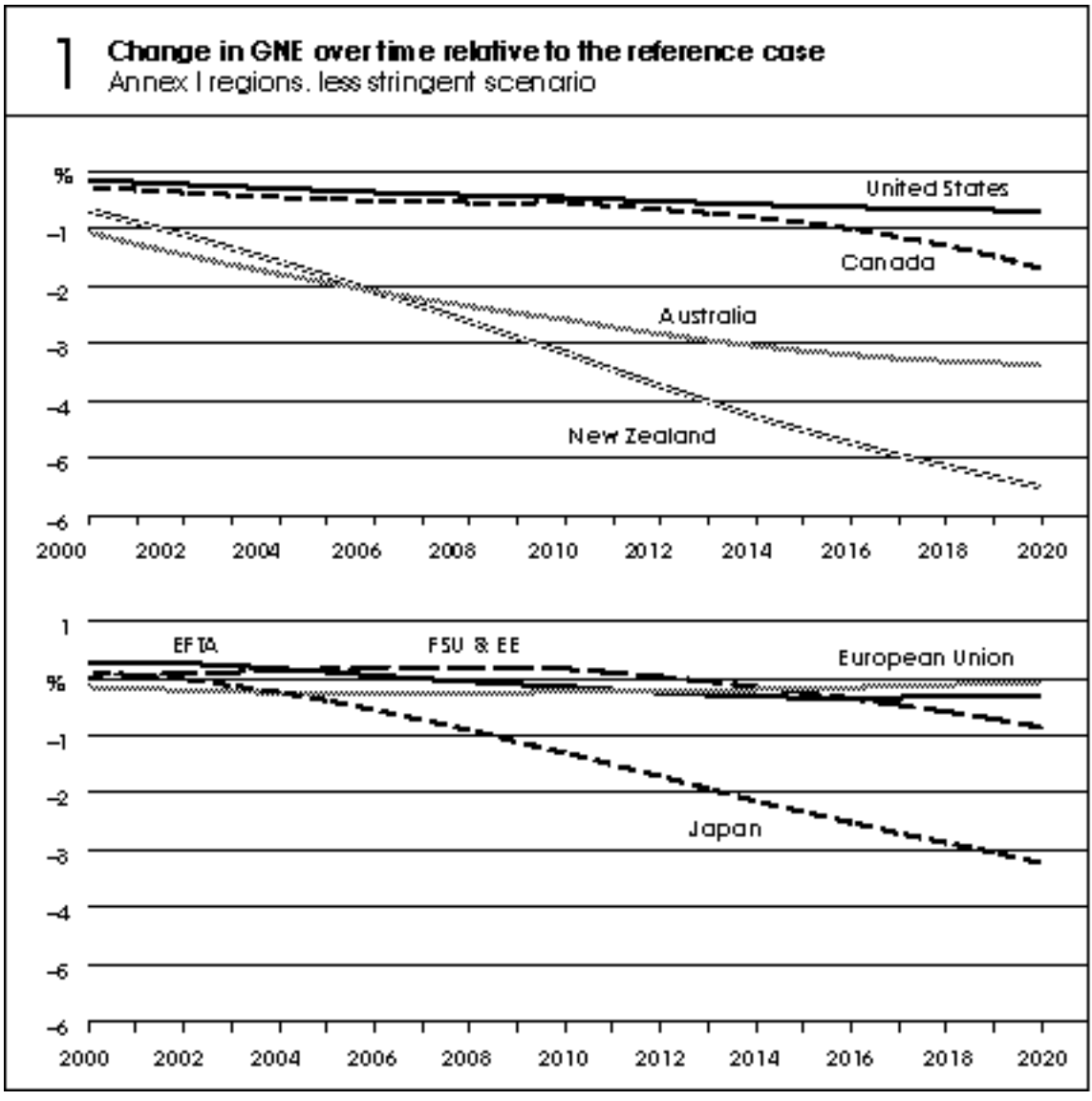
The figures in table 1 represent average outcomes across broad regional groupings. However, within groupings there are substantial differences in outcomes owing to differences in economic structures and trading patterns. The magnitude and sources of these differences in Annex I regions are considered below.

Differences in economic impacts among Annex I countries

The economic losses incurred by Annex I countries under the less stringent emission reduction scenario are shown in figure 1. These losses are presented as the change in gross national expenditure (GNE) over time relative to the reference case. In most Annex I regions annual GNE cases are projected to increase over time. For example, under the less stringent emission reduction scenario, the annual loss to Japan is projected to more than double between 2010 and 2020, from 1.3 per cent to 3.2 per cent of GNE relative to the reference case. Over the same period the loss to Canada increases from 0.5 per cent to 1.7 per cent of GNE.

In contrast to the other Annex I regions, the European Union exhibits decreasing GNE costs over time. This is principally the result of a growing competitive advantage over other Annex I countries in the production of some energy intensive products.

The results presented in figure 1 show that GNE losses are projected to vary significantly between Annex I regions. For example, the projected costs for Australia, New Zealand



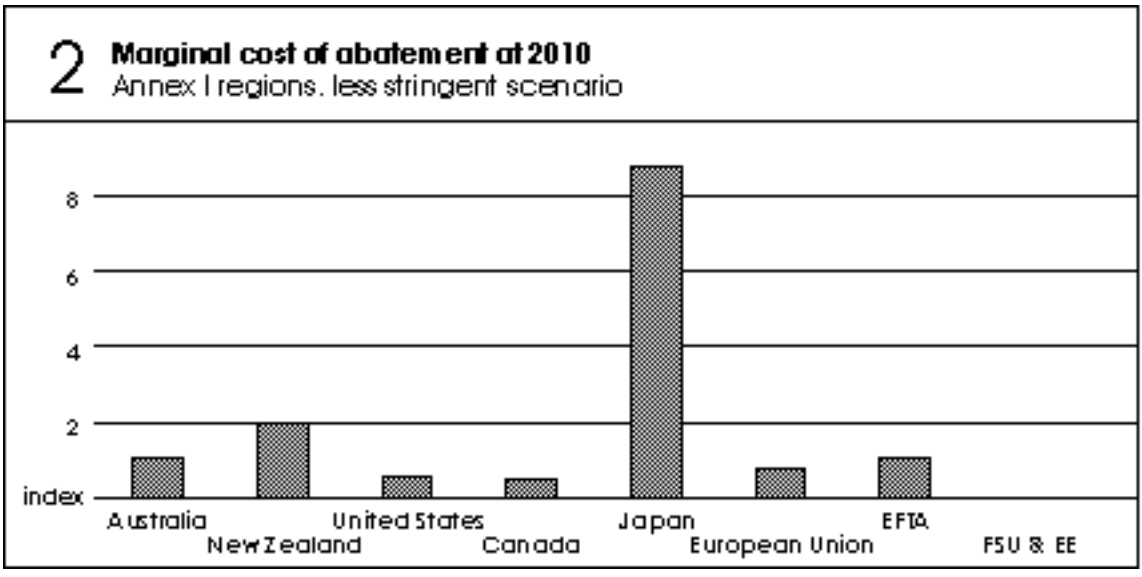
and Japan are many times higher than those projected for the other Annex I regions by 2020. For all regions, projected costs are higher under the more stringent scenario.

Impacts on production

Marginal costs of abatement

The production impacts of achieving a given emission reduction in Annex I regions will depend to a large extent on the size of the penalty that is needed to be put in place to discourage emission generation. The marginal cost of emission abatement is a measure of this penalty.

Marginal emission abatement costs under the less stringent scenario at 2010 are shown in figure 2. In this figure, the marginal emission abatement costs have been normalised so that the average marginal abatement cost across Annex I countries (weighted according



to 1990 emission levels) is set equal to 1. The projected marginal abatement costs for Australia and the European Free Trade Association (EFTA) are approximately equal to the Annex I average, while the projected marginal abatement cost for Japan is about eight times the Annex I average.

The size of the marginal abatement cost for each Annex I region depends on two main factors:

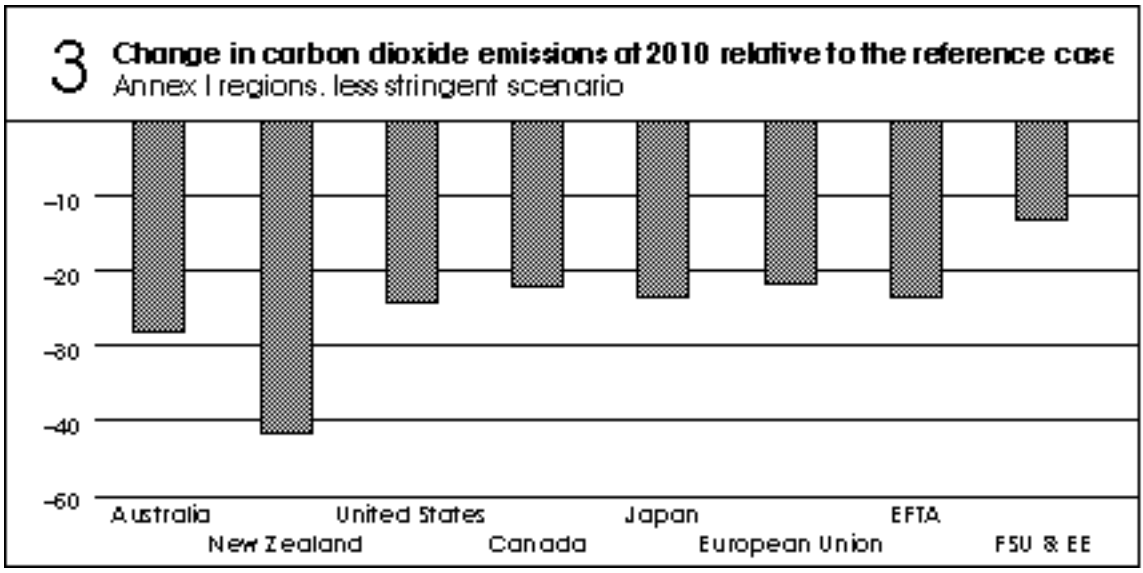
- the magnitude of the emission reduction required; and
- the cost of fossil fuel alternatives.

Magnitude of the emission reduction

As an emission abatement target is increased, low cost options to reduce emissions become more scarce. As a result, the penalty for generating emissions must be increased in order to encourage firms and consumers to adopt alternatives to emission intensive fossil fuels. This implies that marginal emission abatement costs will tend to be higher for countries with higher emission abatement targets relative to the reference case.

Estimates of the required emission abatement for each Annex I region are presented in figure 3. Countries with relatively high reference case emissions growth, such as Australia and New Zealand, are required to achieve relatively large emission reductions to meet their emission abatement objectives under the uniform targets approach. This contributes to their high marginal cost of emission abatement.

Under the less stringent emission reduction scenario the former Soviet Union and eastern Europe grouping is not required to undertake emission reductions until after 2007 as their



emissions are not projected to increase above 1990 levels until that year. This is reflected in the results presented in figure 3 by the relatively small emission reduction requirement for this region. It should be noted, however, that by 2020, with the significant growth in emissions from the former Soviet Union and eastern Europe, this region will be required to reduce emissions to more than 40 per cent below reference case levels. This compares with the estimated 30 per cent reduction for the United States in the same year.

The cost of fossil fuel alternatives

While emission abatement targets are closely related to marginal abatement costs, the extent and expense of possible alternatives to carbon intensive production processes are also important determinants of marginal and, ultimately, total emission abatement costs.

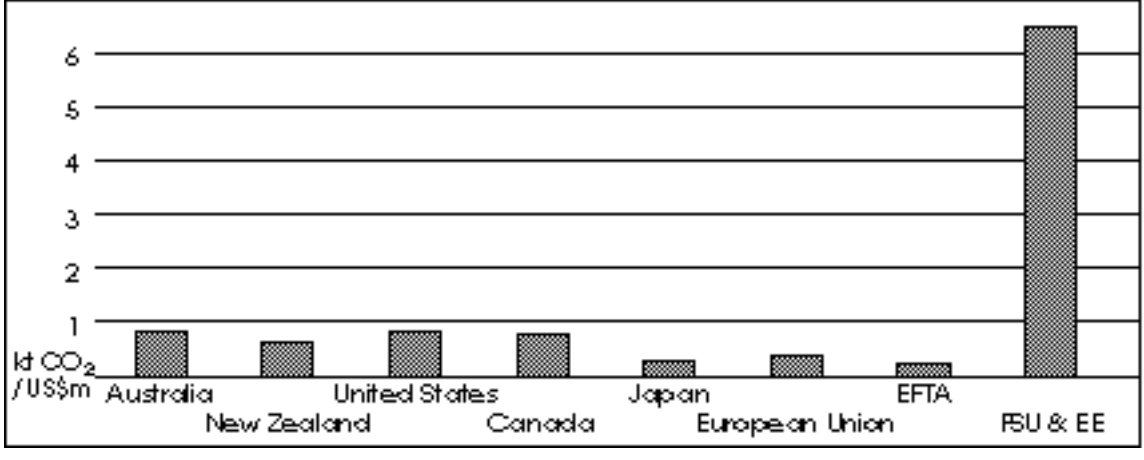
A region that can substitute readily into less emission intensive fuel sources would be expected to incur a relatively low marginal abatement cost and experience lower economic costs than a region with limited, or more expensive, substitution possibilities, all other things being equal.

Substitution possibilities can be limited if a region uses technologies that are relatively less emission intensive. In this case the region is said to have limited technical possibilities for substitution. For example, a country that is heavily reliant on hydroelectricity or nuclear power will not have significant scope to achieve low cost emission reductions in the electricity sector. This would imply a need to reduce emissions in the transport and industrial sectors, where substitution possibilities tend to be more limited and where higher penalties or marginal emission abatement costs would need to be imposed to encourage emission reductions.

Technical substitution possibilities are likely to be especially limited in Japan which has achieved significant reductions in fossil fuel use over the past twenty-five years in most sectors of its economy. As a result, low cost options to reduce fossil fuel use that might have existed are likely to have been exhausted in the past and, therefore, Japan will need to impose substantial penalties on emitters in order to achieve further emission reductions. This will be reflected by a relatively high marginal cost of emission abatement.

In contrast with Japan, the production structure in the former Soviet Union and eastern Europe relies heavily on carbon dioxide intensive inputs (figure 4). This region is likely to have significant low cost opportunities to reduce emissions and, therefore, is unlikely to need to impose substantial penalties on emitters in order to achieve emission reductions in the near future. For the United States and Canada, relatively high emission intensity contributes to their relatively low projected marginal costs of abatement in 2010.

4 Emission intensity of aggregate output in Annex I regions, 1995



Substitution possibilities for a region can also be expensive if alternative, less emission intensive fuels are more costly than the more emission intensive fuel source already in place. In this case the region is said to have limited *economic* possibilities for substitution. For example, Australia has vast reserves of coal that have a distinct price advantage over other potentially less emission intensive fuels, such as natural gas and renewables in electricity generation, given existing capital structures. The penalty for emitting carbon dioxide in this region must rise significantly in order to make coal a less attractive input than other fuel sources and thus for substitution to occur.

GDP and sectoral impacts

A high marginal cost of emission abatement will translate into increases in production costs for industries that use fossil fuels. The increased costs will tend to reduce production

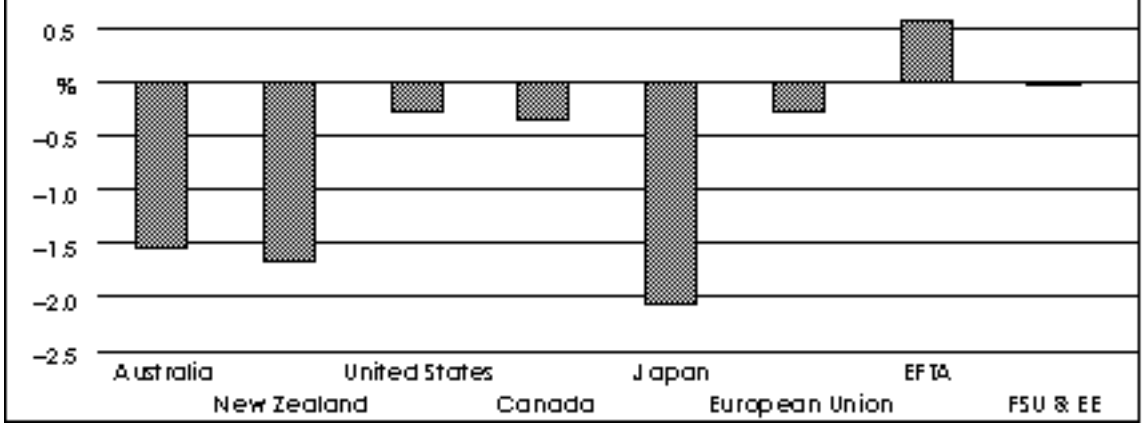
relative to the reference case in most industries and especially in those industries that use fossil fuels most intensively. These include industries such as electricity generation (in some countries), iron and steel and chemicals, rubber and plastics.

There will also be effects on industries that use electricity, such as nonferrous metals smelting. These effects occur because any increases in the costs of electricity production associated with emission abatement are passed on to electricity users.

Emission abatement policies also affect the production of fossil fuels by increasing the costs associated with using fossil fuels in Annex I regions, leading to reduced world demand for coal, gas and oil. This reduced demand will lead to reductions in fossil fuel output in Annex I regions, contributing to reductions in their gross domestic product.

Estimates of changes to aggregate output associated with the less stringent emission abatement policy are shown in figure 5. In general, regions with relatively low marginal emission abatement costs experience a smaller projected increase in production costs than regions with higher marginal emission abatement costs. As a result, fossil fuel using industries in low marginal cost regions will experience smaller reductions in competitiveness and output (on average) than in regions such as Australia, New Zealand and Japan, where the impacts of uniform emission abatement on gross domestic product are projected to be more significant. Aggregate output in EFTA rises, owing to increases in the outputs of a range of energy intensive products. These products receive a substantial competitive advantage over similar products in other Annex I regions because of the relatively low level of reliance on fossil fuels in their production.

5 Change in aggregate output at 2010 relative to the reference case
Annex I regions, less stringent scenario



Reductions in fossil fuel outputs have the most significant impacts on gross domestic product in Australia where fossil fuel production is a more significant contributor to gross domestic product than in the other regions.

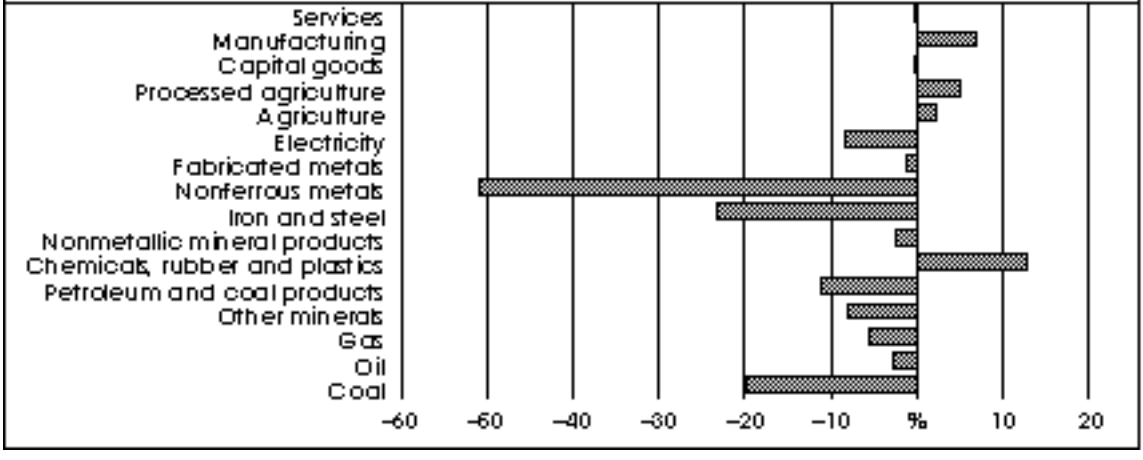
Australian sectoral output

For Australia the most significant output reduction takes place in the nonferrous metals industry (figure 6). This industry (mainly aluminium) uses electricity very intensively and, in Australia, the majority of electricity is generated in coal fired power stations. As a result, the high marginal cost of abatement for Australia (see figure 2) is passed on to nonferrous metals producers through significant increases in electricity charges. This cost increase reduces the competitiveness of the Australian nonferrous metals industry (compared with nonferrous metals industries in other regions where electricity generation is less dependent on fossil fuels), leading to a decline in output from this industry.

Australia's coal output is projected to decline significantly relative to the reference case. This results mainly from a projected reduction in Australian coal exports to other Annex I countries, such as Japan, which reduce coal use with the adoption of emission abatement policies. The impact of reduced demand by Annex I regions on Australian coal exports is ameliorated to some extent by increased demand for coal by some non-Annex I regions (particularly in Asia).

Output for the Australian chemicals, rubber and plastic sector is projected to increase by around 13 per cent relative to the reference case at 2010. The Australian chemicals, rubber and plastic sector is relatively less emission intensive than the chemicals, rubber and plastic sectors in other Annex I countries. The adoption of emission abatement actions throughout

6 Change in Australian sectoral output at 2010 relative to the reference case
Annex I regions, less stringent scenario



Annex I regions therefore provides the Australian chemicals, rubber and plastic industry with a competitive advantage, leading to a projected increase in its exports and output.

Production from Australian manufacturing, agricultural and processed agricultural products sectors is projected to rise relative to the reference case. These sectors absorb labour and capital resources released from the mining and fossil fuel intensive manufacturing sectors.

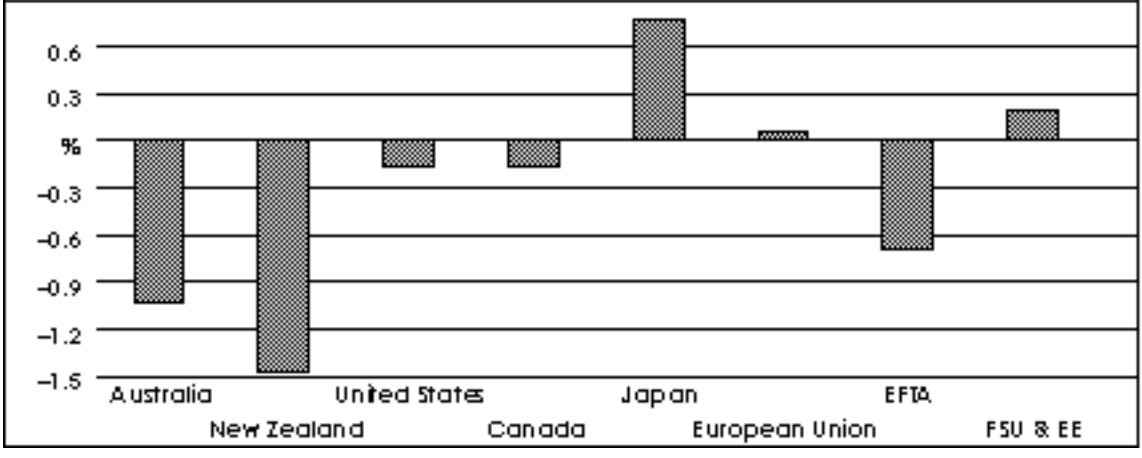
Trade related impacts of emission abatement

While the GDP losses shown in figure 5 are closely correlated with the GNE costs associated with the uniform emission abatement targets, there are differences that relate to the impacts of emission abatement on the capacity of an economy to benefit from trade. The contribution of the trade related impact to the change in GNE is the difference between percentage change in real GNE and percentage change in real GDP relative to the reference case. The contributions of the trade related impacts under the two scenarios at 2010 are shown in figure 7. A positive number indicates that trade related impacts have made a positive contribution to the GNE change while a negative number implies an adverse trade effect. Negative trade effects are large for Australia, New Zealand and the European Free Trade Association.

Kyoto in December

In the very long term the United Nations Framework Convention on Climate Change will be judged to have been effective if a balance has been achieved between the net damage from climate change itself and the economic costs imposed as a result of emission abatement and adaptation. One of the necessary conditions for such a balance is that major

7 Trade related change in GNE at 2010 relative to the reference case
Annex I regions. less stringent scenario



emitters are part of an agreement to reduce greenhouse gases. This type of participation will be encouraged only if emission abatement actions undertaken by signatories are fair and least cost.

A demand for simplicity by some parties to the convention has led them to insist on uniform abatement targets that lead to an unequal allocation of economic costs among Annex I countries. Such an approach does not lay the long term foundation for an agreement that will be implemented wholeheartedly, that will provide a mechanism for signing on developing countries to undertake future commitments, or that will form the basis for introduction of innovative new policies such as tradable emissions quotas.

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