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ENVIRONMENTAL POLICY, INTERNATIONAL AGREEMENTS AND INTERNATIONAL TRADE

SUMMARY FINAL REPORT

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I. OBJECTIVES

The project was designed to analyse two aspects of the international dimension of environmental policy. The first is that for transboundary environmental problems, such as those of climate change and acid rain, it is necessary for countries to engage in some form of international environmental agreement to overcome the well known incentives for free riding. The second is that even if pollution was an entirely domestic concern, countries are linked through trade and environmental policies will affect the international competitiveness of particular sections of an economy; this has led to fears that if governments become concerned about this loss of competitiveness, they may set too lax environmental policies, essentially as a form of covert protection. A counter claim has been that such strategic trade considerations may actually induce governments to set tough environmental policies to give their domestic producers a competitive advantage in developing "green" technologies ahead of their rivals. These two issues are closely linked, since an important consideration for a country deciding whether or not to join an international environmental agreement is the economic cost of having to set tougher environmental policies than at least some other countries, assuming that not all countries do join the agreement. The project was designed to develop both theoretical and empirical economic models to explore these issues. For the second set of issues the innovative feature of the project was that almost all of the extant theoretical and empirical analysis of the link between environmental policy and international trade had assumed competitive markets, and the project aimed to use the developments in the "new trade theory" to reappraise this link for sectors where, because of significant economies of scale, markets were imperfectly competitive. This reappraisal concerns both the size of the impact of environmental policy on competitiveness and the policy implications which have been drawn about the design of environmental policy.

A more specific characterisation of the project was that it attempted to answer four main questions: (a) how can international environmental agreements be designed to increase the number of countries which might join such an agreement; (b) if only partial climate agreements are possible how should policy by the agreeing parties be designed to reduce the extent of "carbon leakage" in the non-signatory countries; (c) when allowance is made for imperfectly competitive markets, is the loss of competitiveness from implementing unilateral environmental policies larger than previously thought; (d) do national governments have incentives to distort their environmental policies to gain strategic trade advantages and if so what form might this take and what does this imply about the sovereignty of nations in choosing environmental policies. Other work was done under the project on market structure and environmental taxation and on endogenous growth theory; these had a single country focus, and were designed as building blocks to address the international questions set out above..

II METHODOLOGY

The project was designed to contain a mixture of theoretical and empirical analysis to illuminate the questions set out in the previous section. In broad terms, the theoretical analysis has been based mainly on the application of recently developed concepts in economic theory to the international environmental context, in particular the concepts of non-cooperative game theory, endogenous growth theory, strategic trade theory and economic geography. The empirical analysis has been more diffuse in its approach, using simulation models, micro-econometrics, and case study material.

To be more specific it will be useful to refer to the research under the four headings set out in the previous section.

a) Design of International Agreements

The work by Carraro and Siniscalco on international agreements was theoretical drawing on non-co-operative game theoretic concepts of coalition formation, coalition stability, trigger strategies as related to the analysis of co-operation on both environmental problems and R&D. Some numerical analysis was also employed. The work by Chander and Tulkens on burden sharing in international environmental agreements was a mixture of theoretical analysis based on concepts of co-operative game theory (various concepts of the core) and empirical analysis of the application of these ideas to an acid rain agreement for the Baltic states, which uses a calibrated simulation model.

b) Design of Partial International Agreements

This work was carried out by Hoel and co-authors and was also a mixture of economic theory (standard trade theory) together with an empirical analysis of how the OECD could design a set of taxes on consumption and production of fossil fuels to minimise the problem of "carbon leakage" to non-OECD countries. This empirical study used data on OECD trade in fossil fuels with associated supply and demand elasticity’s to calculate taxes required to meet a given target for reductions in OECD emissions.

c) Environmental Policy and Loss of Competitiveness in Imperfectly Competitive Trade

This part of the project was mainly empirical and involved three pieces of work. Winters and co-author first used a number of existing models to assess the likely impact of a carbon tax on production costs in different sectors of OECD countries. They then surveyed the existing literature on the factors affecting location decisions of multi-national enterprises (MNEs) to assess whether a carbon tax would be likely to have significant impact on the decisions of MNEs whether to locate in the OECD or non-OECD countries if only the former imposed a carbon tax. Venables and Ulph constructed models of location decisions of firms in imperfectly competitive industries when firms in different sectors have forward and backward linkages between each other. Such models extended the analysis of imperfectly competitive international trade familiar from the literature on strategic trade policy to incorporate agglomeration effects introduced by the literature on economic geography. Venables then calibrated the theoretical model to data on the world chemical industry to analyse the impact of the European countries imposing a unilateral energy tax. Finally the work of Golombek and co-authors used a micro-econometric panel data study of firms in three sectors of the Norwegian economy to study their decisions on whether to expand or contract employment and, in the latter case, whether to remain in the industry. The study compared the behaviour of firms facing different degrees of environmental regulation to test whether more heavily regulated firms were more or less likely to contract employment or leave the industry than less heavily regulated firms.

d) Incentives for Strategic Environmental Policy

This part of the project was entirely theoretical and aimed to assess whether, in imperfectly competitive markets governments would have incentives to set either too lax or too tough environmental policies. The analysis by Lund, Ulph and Ulph used economic models which incorporated multi-stage games of the type familiar from the modern strategic trade literature to address these questions.

III MAIN RESULTS

As in the previous section it is simplest to sketch the main results in terms of the answers the project has provided to the four sets of questions noted in section I.

Design of International Environmental Agreements

There were two strands of work on this topic. Carraro and Siniscalco (1993,1994) considered the question of how many countries will voluntarily agree to join an international agreement to deal with a problem of the global commons such as climate change. In deciding whether to join an agreement, a country weighs the cost of having to cut its emissions against the benefits that other members of the agreement will respond by further cutting their emissions, although this may be partly offset by an expansion of emissions by countries which continue to stay out of the agreement ("carbon leakage"). Carraro and Siniscalco started by considering a stable coalition, that is a group of countries within an agreement such that no country outside the agreement has any incentive to join and no country within the agreement has any incentive to leave. They noted that typically stable coalitions are small and considered what mechanisms might be available to expand the size of the coalition. One mechanism is the use of income transfers, whereby existing members of a coalition use income transfers to induce additional members to join, with the requirement that such transfers be self-financing, i.e. they must not make any member of the coalition worse off than before expansion took place. They showed that these can only work if there are mechanisms by which existing coalition members can commit themselves not to quit as the coalition expands, in which case it may be possible to double the size of the coalition. An alternative device is issue linkage, whereby membership of an environmental agreement is linked to membership of another agreement. The particular example given by Carraro and Siniscalco was that of an R&D agreement, for which they showed that, at least for some parameter values, it would be possible to get all countries to join a linked agreement.

A related line of research was reported in Chander and Tulkens (1994), Germain, Toint and Tulkens (1994). They were also concerned with problems of transboundary pollutions, and the question they addressed was the design of a "cost-sharing" or burden-sharing rule for determining income transfers between countries in such a way that if all countries joined an international environmental agreement then by using the income transfers no group of countries would have an incentive to defect from the agreement. They were able to derive this positive result, in contrast to Carraro and Siniscalco, because they use cooperative game solutions. Their burden-sharing rule was applied to a model of acid rain in the Baltic. The efficient outcome would require two states (Kola and Estonia) to make substantial cuts in emissions, to the benefit especially of North Finland, and the authors calculated the transfers from the other states to Kola and Estonia which guarantee that no country or group of countries would wish to defect from the efficient solution.

How to design partial agreements to reduce carbon leakage

An implication of the work in the previous section is that any agreement on climate change is likely to be partial. Partial agreements lead to the problem of carbon leakage, that is some of the reduction in emissions achieved in

the countries signed up to the agreement may be offset by increases in emissions by countries in the ROW, due to either expansions of production in ROW or to a fall on fossil fuel prices in ROW. However if the countries in the partial agreement are large enough to affect the world markets for fossil fuels, then Hoel (1993) and Golombek, Hagem and Hoel (1993) showed that by an appropriately designed set of tax policies these countries can substantially reduce carbon leakage. Specifically, policy-makers should set taxes on domestic consumption and production of fossil fuels which consists of two elements: (i) a pure carbon tax, which should be the same (per unit of carbon) across all fuels, and which reflects the marginal damage to the agreeing countries caused by *global* emissions; this total tax will be split between a tax on consumers and producers of fossil fuels according to the elasticities of domestic supply and demand; (ii) an "optimal tariff" on imports (exports) of fossil fuels which depends on the elasticity of supply of imports (elasticity of demand for exports); a tariff on imports amounts to a tax on domestic consumption which is rebated to domestic producers; a tariff on exports is equivalent to a tax on domestic production which is rebated to domestic consumers. Depending on the relative importance of the tariff element and the carbon tax element, it is clear that either, but not both domestic consumption or production could end up with a net subsidy. As an illustration, Golombek, Hagem and Hoel (1993) analysed the implications of OECD countries acting unilaterally to cut world CO_2 emissions by 15% relative to the 1990 level. Using estimates of demand and supply elasticities for fossil fuels for OECD and non-OECD countries (including cross-elasticities of demand for fuels), they calculated the optimal structure of taxes on OECD consumption and production of fossil fuels. Since the OECD is a net importer of all fuels, this means that for consumers the import tariff should be added to the carbon tax for consumers, and subtracted from the carbon tax for producers. The analysis showed that the OECD should subsidise domestic production of oil and tax domestic production of coal and gas.

Loss of competitiveness in imperfectly competitive markets

Much of the theoretical and empirical analysis of the trade impacts of environmental policy has assumed competitive markets, and the general conclusion is that environmental policy has small impacts. The research sought to explore whether this was true with imperfectly competitive markets, in particular with respect to the decision on where to locate production activity. One reason for thinking there might be a different effect is that scale economies introduce a lumpiness into producer's decisions, so that over a range, environmental policy may have little impact, but when it reaches a threshold there could be a large effect.

The first empirical study by Wang and Winters (1994) was an attempt to assess the likelihood that a carbon tax unilaterally imposed by OECD countries, might lead multinational companies to relocate their production facilities. They first computed the impact of a unilateral carbon tax ($100/tc) on costs and then surveyed the literature on MNE location decisions to see whether such a cost difference would affect location. Their conclusion was that, given the small impact of a carbon tax on cost differences, and given the importance which the literature suggested that MNE's attached to other factors such as market access, market size, proximity to supplies of materials, macro-economic and stability, "it would be very difficult to believe that imposing a carbon tax in the OECD will cause serious industrial flight from the OECD to non-OECD countries".

The second study addressed directly the argument that what matters in making location decisions is more than just costs of production, but also proximity to markets or sources of supply. For producers in many sectors, a significant fraction of their market will be producers in other sectors while a significant fraction of their inputs will be the outputs of producers in yet other sectors. Thus because sectors are linked in the structure of production, the location decisions of producers become interdependent. This provides incentives for *agglomeration* of producers from different sectors in the same location. There are two implications of agglomeration. First, there is the possibility that with strong inter-sectoral linkages there is the scope for quite catastrophic effects of policy on location decisions of producers when critical thresholds are reached; this can be characterised by the concept that a country can lose its manufacturing base in a particular set of related industries. Second, when agglomeration effects are strong what matters to producers is being located close to producers in related sectors; where that happens to be is less important. This can mean that for a range of parameter values, including policy parameters, there can be multiple equilibria, with an important implication that policy may display a "hysteresis effect". For example, at a low level of environmental taxes in Europe, say, the only equilibrium is for a set of industries to locate in Europe, as the level of taxes rises there may emerge another equilibrium in which the industries could locate in the U.S; but given that the industries started in Europe, no individual producer would wish to switch to the U.S.; when environmental taxes get high enough, it is no longer possible to sustain the industries in Europe, and production would switch to the U.S.; but if Europe subsequently lowers its environmental taxes, by the same argument the producers will not switch back to Europe unless the taxes reverted to the very low level at which location in Europe was the only possible equilibrium.

The theoretical modelling in Ulph, Ingham and Valentini (1994) and Venables (1994) provided a theoretical basis for the intuitions just provided, and the question is whether in practice inter-sectoral linkages are strong enough to provide these kind of effects. Venables (1994) used a model of the world chemical industry. The industry was split into two sectors, basic chemicals and other chemicals. There were four country groups: North America, Far East, Europe, and Rest of the World. The linkage between the sectors was that basic chemicals contribute 25% and 17% of the gross costs of producing basic chemicals and other chemicals respectively, while the corresponding figures for other types of chemicals are 2% and 9%. The policy instrument used was an energy tax imposed unilaterally by Europe (energy accounts directly for about 14% of the gross costs of basic chemicals and 3.5% of other chemicals). When the energy tax rate reaches 50%, this will close down the European basic chemicals industry, with most of the production shifting to North America. Given the moderate strength of the inter-sectoral linkages, there is no catastrophic decline in the industry at a particular threshold nor was there any hysteresis effect. To understand the importance of the plant location decisions, note that at the 50% tax rate per unit, Europe suffered a 14% loss of competitiveness relative to the US. Only half of this can be accounted for by the effects of the energy tax on costs (both directly and indirectly through the higher costs of intermediate inputs). The rest of the cost increase is accounted for by the fact that suppliers are relocating to North America. Thus agglomeration effects have doubled the impact of the energy tax.

The final piece of empirical work was a detailed study of the impact of environmental regulation on Norwegian firms in three industrial sectors by Golombek and Raknerud (1994). They considered two aspects of how firms evolve over time; would they survive or shut down (exit); if they survive would they expand or contract employment. Firms were classified into regulated and unregulated, and the research covered the three most heavily regulated sectors - paper and pulp; iron and steel and basic chemicals. The model estimated the probabilities in any one period of a firm expanding employment, contracting employment, or exiting the industry for regulated and unregulated firms. The research derived the interesting result that, at least in the first two industries, regulated firms are significantly less likely to close down and are more likely to increase employment rather than to decrease employment.

Incentives for distorting environmental policy

If imperfectly competitive industries increase the impact of environmental policy on loss of competitiveness, as some of the work reported in the previous section has suggested, does that provide governments with any incentive to relax their environmental policies, as environmentalists fear, or does a more dynamic view of market competition suggest that governments may wish to set rather tough environmental policies as a spur to "green" R&D? This has been the subject of theoretical work carried out by Lund (1993), Ulph (1994 a,b,c,d) and Ulph and Ulph (1994). A brief summary is as follows, (i) While it is certainly possible to construct models where governments would indeed have incentives for "ecological dumping", these results are not at all robust, with respect to both the magnitude of the extent of any economical dumping and indeed whether the incentives go the other way and require governments to set too tough environmental policies. The factors which influence the magnitude and direction of any distortion to environmental policy include: the nature of competition in the product market, the choice of environmental policy instruments by government, and whether or not producers are also trying to shift market share in their favour, for example by their investment in capacity; (ii) In the case where producers can engage in green R&D, there are no robust theoretical arguments for believing that governments should set too tough environmental policies, for two reasons. First, it is not always the case that tougher environmental policies encourage domestic producers to want to do more R&D; second, even if tougher environmental policies did induce domestic producers to do more R&D, there remains the rent-shifting arguments noted in (i) which induces relaxation of environmental policy.

IV. SCIENTIFIC INTEREST AND POLICY RELEVANCE

I Scientific Interest and Novelty

The work of Carraro and Siniscalco was one of the earliest papers to provide a rigorous analysis of the concept of issue linkage and to demonstrate the circumstances under which such linkage will be beneficial.

The work of Chander and Tulkens has provided a new discrete-time analysis of the dynamics of environmental agreement and has shown that this dynamic process can converge in a finite number of steps.

The work of Ulph and Ulph has extended the analysis of the impact of environmental policy in imperfectly competitive markets to allow for the possibility that producers as well as governments act strategically, and so capture the impact of environmental policy on investment decisions such as R&D decisions (previous analysis of environmental policy and R&D ignored the fact that there is a strategic dimension to the R&D decisions of producers).

The work of Ulph and Venables has extended the analysis of the impact of environmental policy on location decisions to allow for agglomeration effects; while the importance of such effects has been recognised, it is only recently that a rigorous analysis of such effects has been possible and this project brought such analysis to bear on international environmental policy issues.

The work of Golombek has introduced the use of micro-econometric analysis of firm level data to study the impact of environmental regulation on employment and exit decisions of firms.

II Policy Relevance

The work of Carraro and Siniscalco showed that there may be limits to the use of income transfers as a means of encouraging additional countries to sign up to international environmental agreements and that the use of issue linkage, particularly between environmental agreements and technology transfer agreements may be a more successful way of expanding the number of signatories to an international environmental agreement.

The work of Chander and Tulkens derived a rule for burden sharing amongst signatories to an international environmental agreement which ensures that countries will not defect from the agreement. While the rule has a straightforward interpretation it is more sophisticated than *ad hoc* rules often proposed for burden sharing.

The work of Hoel showed how a group of countries who decide unilaterally to introduce a carbon tax to reduce CO_2 emissions can design the carbon tax in a more sophisticated way (as a set of taxes on consumers and producers of fossil fuels within their countries) so as to reduce the scope for "carbon leakage" arising from reductions in the prices of fossil fuels in countries outside the agreement.

The work of Venables and Ulph showed that if there are very strong linkages between producers in different sectors of the economy, then the unilateral imposition of environmental policy by a group of countries can have a "catastrophic" effect (i.e. the policy has little effect until a critical threshold is reached, when it triggers a very large response). Moreover such policy effects can display a "hysteresis effect", i.e. reversing the policy will not reverse the effect of the policy. This suggests the need for considerable caution in policy making in cases where inter-sectoral linkage effects may be strong.

The work of Golombek showed, for some Norwegian industries, that environmental regulation need not always be damaging to industry in terms of loss of employment (in the extreme case, the collapse of firms); while the analysis could not show why this result occurred, the authors suggested that it reflects either that producers were inadequately informed about technologies which could both reduce emissions and raise productivity ("no regrets strategies") or that regulation stimulated innovations which allowed expansion of employment.

Two commonly held views about how governments may set environmental policy when faced with competitive international markets are the view of environmentalists that governments will be tempted to set lax environmental policies as a form of covert protection, and the opposite view that governments should set very tough environmental policies to encourage domestic producers to innovate "green technologies". The analysis in this project (by Lund, Ulph and Ulph) showed that while it is possible to construct economic models which support either view, these conclusions are not at all robust. There can be no presumption that either view is correct. It is an empirical question whether tough environmental regulation will stimulate R&D and it is also an empirical matter whether governments have significant incentives to relax environmental policies.

The last set of conclusions have implications for debates over issues such as subsidiarity in environmental policy. One reason that was advanced for the European Community to play a role in environmental policy, even if environmental damage is of concern solely to an individual nation state, is the concern that governments may use environmental policy as a covert for of trade protection. This leads to suggestions that the European Community should set harmonised environmental standards, or at least minimum environmental standards. The analysis in this project showed that such arguments cannot be given general support. Harmonisation is not desirable because it tends to ignore important differences between countries; minimum standards may not be appropriate because the distortion to environmental policy need not take the form of governments setting too lax standards but rather setting too tough standards, and minimum standards would make this situation worse.