Exploring the relationship between environmental regulation and competitiveness – Literature Review

Final Report to the Department for Environment Food and Rural Affairs

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SQW Quality Statement

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Executive Summary

The purpose and conduct of the review

1. SQW Ltd was commissioned by the Department for the Environment, Food and Rural Affairs (Defra) to carry out a literature review of the relationship between environmental regulation and competitiveness to establish the robustness of the conclusions from the available evidence and their relevance for the UK.

2. The search of the literature was accomplished by investigation of the following sources – ISI Web of Science, JSTOR, Elsevier, Sciencedirect, institutional websites (such as OECD, World Economic Forum, DTI, AEI Brookings Joint Center for Regulatory Studies and Resources for the Future), specific academic journals (such as the Journal of Environmental and Resource Economics) and the bibliographies in the most cited articles. Where possible, all searches were limited to peer-reviewed journal articles in English and working papers and discussion papers published by prominent research institutions. The literature search was assisted by consultations with UK government departments and agencies and academics.

3. Over 130 key articles, papers and reports were identified as being relevant and were reviewed. About half of these represented empirical work or case studies – almost two thirds of which were based on US/Canadian evidence. The dominance of the latter is attributable in large part to the introduction of environmental regulations through the Environmental Protection Agency from the early 1970s and the concerns that were raised about their potential impact on US productivity and income growth. The development of European literature has been a fairly recent phenomenon and there remains a paucity of research based on UK experience.

Definition and measurement of the key variables

4. The literature reveals some fundamental disagreements on the definitions of the key variables of competitiveness and regulation. Moreover, even when the terms are defined, they have proved difficult to measure. This is particularly so when it comes to measuring whether regulation is more or less stringent or flexible.

5. These problems have increasingly been resolved as the debate in the literature has become more refined and focused in terms of the propositions being set and tested. These propositions (and the definitions they use) have been tested in the following broad ways:

   - Macroeconomic modelling of the effects on national income and productivity growth from more stringent environmental regulation as measured in physical terms (e.g. the number of air and water pollution related inspections) or costs (e.g. from the US Pollution Abatement Costs and Expenditures (PACE) survey;

   - Econometric analysis – both cross-sectional and longitudinal – of patterns and changes in the net exports of goods and services that are subject to more stringent regulation in one country compared with others;

- Case study and econometric analysis of shifts in the patterns of investment flows and in the location of production of pollution intensive goods and services away from locations (countries or regions) with more stringent regulations;

- Econometric analysis of changes in inter-sectoral productivity and innovation in response to more stringent regulation;

- Bottom-up modelling and case studies of how specific sectors or firms respond to increased stringency of regulation.

6. There remain two variables that have proved difficult to nail down but are key in defining to what extent and under what conditions regulation exercises adverse or positive effects on competitiveness.

    - **Forms of regulation:** There is little from the literature that helps define or capture the form of regulation – especially, in terms of the way it gives flexibility for business responses at the same time as it achieves its environmental objectives.

    - **Responses by business:** There is evidence on the resource inefficiency of businesses but it has proved difficult to express this and their willingness/capacity to adapt in indicators and measures that lend themselves to quantitative modelling

7. It should also be noted that much of the empirical evidence draws from the manufacturing sector and from the most pollution intensive sectors within it. There is little evidence available from the services sector.

Macroeconomic effects of increased regulation

8. The limited amount of general equilibrium and econometric modelling suggests that regulations are unlikely to increase competitiveness (econometric models) and may adversely affect it (general equilibrium models). This may be due to the resource efficiency assumption on which the general equilibrium modelling is based. Moreover, the adverse effect can, to varying degrees, be offset by:

    - **Revenue neutrality policies:** Increase or introduce reductions in corporate or personal taxation equivalent to the increase in cost associated with the imposition of environmental taxes or cost increasing controls.

    - **Level playing fields:** Negotiate for the extent and nature of regulation to be multilaterally agreed amongst competing nations and regions.

    - **Awareness and investment promotion:** Ensure that businesses are made aware of the regulations and prompt them (through advisory and grant support) to invest in improved operating practices.

Trade effects of regulation

9. The evidence seems consistently to be that the costs imposed by tighter pollution regulation are not a major determinant of trade patterns even for those sectors most likely to be affected by such regulation. However, there is some evidence that regulatory stringency may exercise an influence once account has been taken of the factor intensity of the different industries and the relative factor abundance of countries. Thus, for a country in which a specific production factor is relatively scarce and an industry intensively uses this factor, then even a modestly stringent environmental regulation will induce a decline in exports.

Regulation effects on investment flows and location

10. Like the studies of trade flows, the evidence on investment and locational patterns suggests that their determinants are complex and that the stringency of regulations must be regarded as one – and often a modest one - amongst a variety of influences at work with more or less significance depending on other conditions.

Effects of regulation at sector, firm or plant level

11. Inter-sectoral studies tend to reveal that generally there is a modest productivity penalty in the short term associated with increased stringency of regulation. But, they also provide evidence of a countervailing innovation push over the longer term – especially in larger firms with a track-record of innovation.

12. Sector specific studies find further evidence of induced innovation and efficiency gain effects that stringent regulation can prompt. The mechanisms by which this happens – and the circumstances in which it is most likely to occur - are not well defined in the literature. The studies also suggest that the extent of market power and the ability to pass through increased costs to the consumer are critical in determining the extent to which regulation has adverse effects on business performance.

13. Finally, firm specific studies show that there are a good many businesses that are located within the production possibilities frontier and for whom regulation creates the possibility for both increased productivity and reduced emissions. The question that is not readily answered in the literature is how to make those possibilities more systematically available, identified and pursued through the design and implementation of the regulations.

The influence of regulatory form

14. It is acknowledged generally in the literature that the form of regulation is likely to matter as much as – if not more than - its stringency in influencing competitiveness. There are many theoretical contributions to the literature that advance the case for market based instruments (e.g. taxes) as being more efficient than command-and-control regulations (e.g. pollution ceilings, technology standards). But, very few studies have provided empirical evidence on this proposition – in part because of the difficulties of measuring the form of the regulations. Moreover, some of these studies do not confirm the greater efficiency of market-based mechanisms although that may be, in part, because the regulations in question have been moderated to cater for the vested interests of incumbent firms.

15. There is strand in the recent literature that suggests – more from a theoretical than an empirical standpoint – that even genuine market based mechanisms may not necessarily generate productivity as well as environmental outcomes where the firms involved are locked into old technological trajectories. This has been termed "path dependency" and, it is argued in some parts of the literature, will only be addressed if regulation based on market mechanisms is incorporated in a wider package of measures designed to bring about general improvements in resource use.

Research questions posed in the literature

16. The more recent literature has sought to move the debate on by identifying the research questions that should have priority in the future. Broadly, the recommended priorities are about giving consideration to the kinds of policies and the nature of the private sector institutions that are most likely to generate innovative and low cost solutions to environmental problems. Three particular strands of interest can be identified within this broad topic:

- The costs and benefits of different forms of market-based regulatory instruments and associated measures;
- The broader policy packages and their components that can enable businesses to respond more effectively to more stringent regulations; and
- The role of technology and innovation in providing a response to more stringent regulation in ways that achieve both competitiveness and environmental outcomes.

Relevance for the UK and its research priorities

17. The lessons from the debate on regulation and competitiveness will be relevant to the UK because of generally increased concern to come to grips with current environmental challenges. It is also because of the trade competitive advantage that the UK enjoys in some sectors that are highly energy and pollution intensive (e.g. chemicals). The lessons are also relevant from an environmental policy perspective in that they are consistent with and help to reinforce the need to design and implement packages of measures that complement the use of economic instruments.

18. The case for such packages has recently been advanced by the Carbon Trust which has also commissioned a good deal of research on the impact of various package options on both carbon emissions and competitiveness. This has helped to make good the paucity of UK evidence in this area. Further research work could include:

- Analysis of inter-sectoral patterns and trends in UK competitiveness to identify the influence of environmental regulation and where increased regulatory stringency could be potentially damaging to competitiveness if handled inefficiently (e.g. chemicals).
- Investigation of the effectiveness of different forms of environmental regulation and complementary measures in competitive non-energy intensive sectors with high fuel use and/or high environmental protection spend relative to their value added and populated by small and medium-sized firms (e.g. in mechanical engineering and business services).

- Assessment of the impact of regulation on innovation within specific sectors or firms that are pollution intensive where intensified regulation could challenge their marginal competitive advantage (e.g. food, drink & tobacco and glass, ceramics & cement). A retrospective and longitudinal study of these sectors would be particularly valuable to explore the effectiveness of their response to a variety of regulatory regimes – especially through technological innovation.

Case Studies

19. There have been some recent contributions to the literature that provide case studies of the way in which individual businesses and industries have responded or might be expected to respond to increasingly stringent environmental regulation in a UK context. They cover some of the sectors referred to above in the recommended areas for further research (e.g. large energy intensive sectors such as chemicals). We suggest that Defra might like to consider building on these case studies to demonstrate the ways in which such regulations affect competitiveness. The details of these case studies are covered in Chapter 5 and in Annex F.

1 Study purpose and method

Study purpose

1.1 SQW Ltd was commissioned by Defra in October 2005 "*to carry out a literature review of the available evidence on the relationship between environmental regulation and international competitiveness*". An initial piece of in house research into the theory underlying this topic had indicated that there were three main issues to consider:

- how to define competitiveness;
- the validity of the conventional argument that regulation reduces competitiveness through raising costs to business and;
- the validity of the Porter hypothesis suggesting that environmental regulation could spur technological growth, leading to an increase in productivity and providing greater environmental protection.

1.2 Issues to be considered whilst reviewing the literature were to include:

- What elements of environmental regulation have more/less of an impact on a firm's ability to innovate? E.g. stringency of regulation, consultation, advance warning of regulation etc.
- What issues affect the impact of regulation on competitiveness? E.g. size of industry, size of firm, type of pollutant, quantity of pollutant, type of regulation etc. and
- Why might some firms not react to regulation through innovation and technical change?

1.3 The robustness of evidence and its relevance to the UK were to be described, and the basis for this given (e.g. date of study, country of study, independence of study etc.).

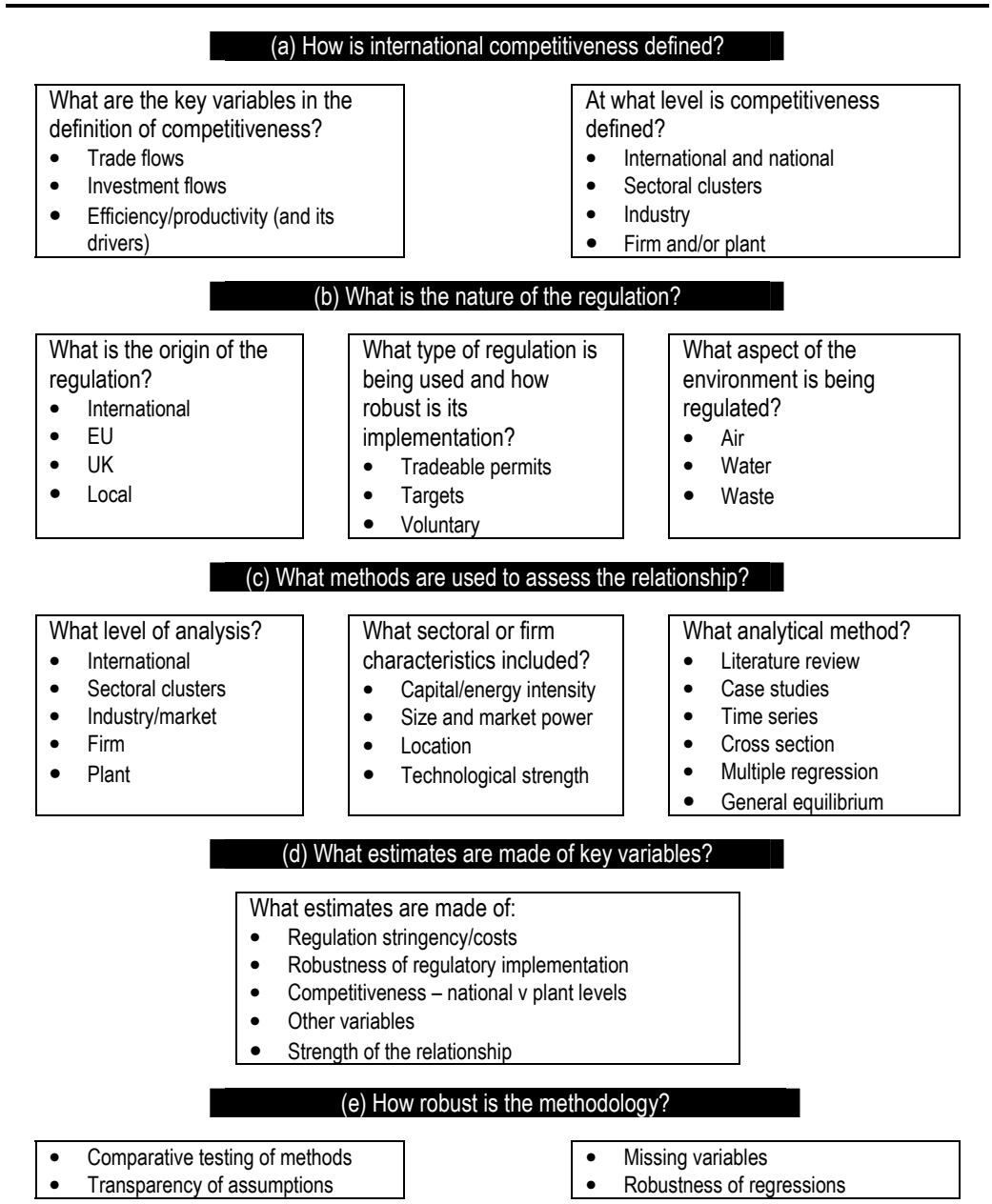
1.4 Included in the report was to be an assessment of the following policy questions based on the latter considerations in the light of the literature reviewed:

- Is there any evidence either in the UK or internationally to support the Porter hypothesis?
- Are there any examples of firms relocating due to the implementation of environmental regulations?
- Do countries with more stringent environmental regulation regimes display signs of being less competitive internationally?

Assessment framework

1.5 The first step in carrying out the review of the literature was to establish a framework linked to the purpose of the study that would enable us to interrogate the literature for its salient points and summarise the key findings. This framework (see Figure 1.1) was designed and agreed with Defra and was, itself, based on some of the literature reviews that have already been conducted in this area.

Figure 1.1: Assessment framework for the conduct of the literature review



1.6 It is evident from the framework that we had some expectations – in part derived from the existing meta-analyses and literature reviews - about the factors that ought to be taken into

account when reviewing and assessing the literature on the relationship between environmental regulation and competitiveness. For the sake of transparency, we set out these expectations as follows:

- The relationship between environmental regulation and competitiveness might vary depending on the level at which the analysis is conducted and the definitions of regulation and competitiveness that are used. For example, a regulation which adversely affects the competitiveness of an individual plant or firm may not appear to do so at more aggregate levels – i.e. the sector or nation – because other businesses or sectors may be able to adjust in ways that offset the shock to the adversely affected plant or firm.

- The relationship might also vary depending on the source of the regulation, its type and the environmental assets it is seeking to protect. Thus:

  - An internationally sourced regulation might still keep the 'playing field' level and not change the relative competitiveness of the players;

  - Different types of environmental regulation may provide more flexibility and time for the affected parties to manage the uncertainties and institute adjustment strategies;

  - More effective management of some environmental assets may be more closely bound up with firm or plant level productivity improvements than others – thus, more effective waste management may bring immediate and significant cost savings to a business in a way that reducing the CFC content of its activities and outputs might not.

- The methods of assessing the relationship may also generate different estimates of the direction and strength of the effect of regulation on competitiveness. Thus, longitudinal or time series studies can allow for the passage of time and the dynamic adjustment process to an extent that cross-sectional studies (even at different points in time) would find more difficult.

- The relationship may vary depending on the characteristics of the businesses and sectors concerned. So, for example, market power may confer on some businesses the ability to pass on any increased costs from regulation to the consumer. Taking account of these factors in the methods of assessment may be critical in understanding the nature of the relationship between regulation and competitiveness.

- Finally, the apparent strength or even direction of the relationship may be dependent on the extent to which the relevant variables can be measured accurately (e.g. regulatory stringency will invariably be problematic in these terms) and on the degree to which the overall adjustment process can be modelled (e.g. a general equilibrium model is likely to offer different outcomes from a comparative static analysis at sectoral level).

Literature search and review

1.7 Once we had established the analytical framework, we developed a template based on it which we could use to interrogate the literature and summarise its key findings in a consistent and comprehensive way. The template is included at Annex A.

1.8 The literature search was conducted using online research databases and citation indices (see Annex E for a description of the process of literature search) to identify relevant economic literature. We have identified and reviewed over 130 academic and other articles, papers and reports. We have classified these as shown in Figure 1.2.

Figure 1.2: Summary of the results of the literature review	
Report Type	**Number**
Commentaries - articles or notes which do not provide a review of the literature, case study examples or empirical work but reflect on some aspects of the debate	14
Literature Reviews - papers which do not present new empirical work but summarise and draw ideas and conclusions from previous studies	17
Case Studies – provide descriptive accounts of the responses of firms to specific regulations but do not conduct any modelling or data analysis and do not provide estimates of the effects	7
Empirical work – carrying out some degree of modelling and data analysis and attempt to provide an assessment of the direction, scale and/or nature of the effect on competitiveness	65
Theoretical Papers – Papers which undertake a discussion or analysis of relevant theories, and which may conduct modelling without using date	20
Other – policy and practitioner related	8
Total	**131**
Note: A full bibliography is included at Annex B	

1.9 The allocation shown in the figure was based on a subjective judgement which placed the literature in the hierarchy depending on which element - literature review, case study or empirical research - formed the main body of the work.

1.10 Table 1.3 provides a breakdown of empirical studies spatially, to illustrate the origin of the literature, defined by the origin of the data used in a particular study. While half of all papers originated in the US, a third had their origins in either EU, UK or specific EU countries.

Figure 1.3: Summary of the origin of the literature	
Empirical and Case Study Reports	**Number**
International/ both US and UK	4
OECD	2
US/Canada	40
EU (including papers focusing on single EU countries other than the UK)	18
UK	6

Figure 1.3: Summary of the origin of the literature	
Empirical and Case Study Reports	**Number**
Other	2
Total	**72**
Note: A full bibliography is included at Annex B	

Consultations

1.11 As part of this project, we held consultations with central government departments and agencies and academics. Our discussions have been guided by the framework we have adopted for the review and have sought to identify the evidence base which was thought to be most persuasive and any implications that there might be for regulatory and other policies in the UK. We consulted with the Carbon Trust, the Better Regulation Team at Defra, DTI and the Environment Agency and with two of the leading researchers in this field.

Structure of the report

1.12 The report on the review findings is presented as follows:

- **Chapter 2: Definitions of competitiveness and environmental regulation** - considers the definitions used in the literature and their relevance to the debate about the nature of the relationship between them;
- **Chapter 3: Evidence on the nature of the relationship** - provides an assessment of the relationship between environmental regulation and competitiveness in terms of the impact on macro productivity growth, trade effects, investment flows and location and sectoral, firm and/or plant level performance;
- **Chapter 4: The influence of regulatory form** – introduces the debate in the literature on the influence that regulatory form can have on competitiveness;
- **Chapter 5**: **Implications for the next steps** -.considers the relevance of the literature for the UK and suggests future research areas.

1.13 There are six supporting annexes. Annex A presents the template we used to interrogate and summarise the literature; Annex B provides a bibliography of the literature; and Annex C gives an account of the empirical work that has been done on the relationship between environmental regulation and competitiveness and the quantitative assessments of the relationship to which it gives rise. Annex D summarises the evolution of the environment-competitiveness debate and Annex E explains our literature search methods. Finally, Annex F provides details of methodologies and results from three potential case studies identified in the literature.

2 Definitions of international competitiveness and environmental regulation

Introduction

2.1 The Terms of Reference for this review required exploration of the relationship between environmental regulation and international competitiveness without being prescriptive about the definitions of these terms. However, it quickly became evident from the review that the definitions could be material to the nature of the relationship. Therefore, we thought it necessary to give some initial consideration to the definitions that have been used and why they might matter.

International competitiveness

2.2 There are a few preliminary points that need to be made about the definition of international competitiveness even if they may seem a bit obvious. First, the benchmark it implies is an international one – i.e. it refers to the success with which a country, a sector or industry, and/or a firm or an individual plant competes against overseas counterparts. Second, competitiveness can be measured in terms of international trade or investment flows but, as the OECD, the World Economic Forum, the European Commission and the UK Treasury and DTI acknowledge, at the national level, the term should also refer to more deep-seated, endogenous characteristics (see the definitions in Figure 2.1).

Figure 2.1: Definitions of international competitiveness

- 'The degree to which (a country) can, under free and fair market conditions, produce goods and services which meet the test of international markets, while simultaneously maintaining and expanding the real incomes of its people over the longer term' (OECD)
- "High and rising standards of living of a nation with the lowest possible level of involuntary unemployment, on a sustainable basis' (EC Competitiveness Report)
- "That collection of factors, policies and institutions which determine the level of productivity of a country and that determine the level of prosperity that can be attained by an economy" (World Economic Forum - Global Competitiveness Report)
  - quality of the macroeconomic environment
  - the state of the country's public institutions
  - the level of its technological readiness
- The Business Competitiveness Index (World Economic Forum) focuses on the underlying microeconomic factors determining levels of productivity and competitiveness in economies. The index measures two areas – sophistication of company operations and strategy and the quality of the overarching national business environment in which they are operating.
- Macroeconomic stability, employment rate, output and trade liberalisation, output per head, quality of life and labour productivity (DTI Productivity and Competitiveness Indicators) with indicators for five drivers of productivity - investment, innovation, enterprise, skills and competitive environment.

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2.3 Third, the concept of international competitiveness can be considered at different levels of aggregation. Individual plants within the same firm may vary considerably in their competitiveness relative to the average for the firm; similarly, industry or sectoral competitiveness will be the reflection of a wide range of performance amongst its constituent firms – with, typically, a long tail of low performing businesses; and a nation's competitiveness will be the outcome of a disparate array of performance at sector, firm and plant levels and the responsiveness of the exchange rate, real wages and other factor prices to the relative performance of the economy.

2.4 The level of aggregation at which any analysis of competitiveness and its drivers is conducted may well be material to the conclusions that can be drawn about the impact of regulation – what may affect one plant adversely may not affect firm, sectoral or national competitiveness in the same way. This is recognised in the literature we reviewed and, for this reason, we provide a separate account of the competitiveness definitions used at the national, sectoral and firm levels.

. . . at the national level

2.5 The most commonly used national level measures of international competitiveness in the literature we reviewed have been levels and growth of Gross Domestic Product or Gross National Product (Jorgenson, 1991), GDP per capita (Porter and Esty, 2001) and international trade flows (Mulatu et al, 2001). This reflects the broad notions of competitiveness quoted in Figure 2.1.

2.6 Whilst we think this broad concept of competitiveness is appropriate, we also suggest that the use of generic and national competitiveness measures (such as growth in GDP per capita) is attended by all sorts of problems in understanding the distinct impact of environmental regulation on competitiveness. Not least, at this level of aggregation, there will be the problem of identifying the separate contribution of regulation amongst the many other influences on competitiveness.

2.7 However, Krugman's (Krugman, 1994) scepticism about the usefulness of the general notion of national competitiveness runs deeper than this, as does Wagner's concern (Wagner, 2003) with the preoccupation that he saw in the literature with national trade performance as a competitiveness measure. As is pointed out in the OECD review of environmental taxes and competitiveness (OECD, 2003), "the principle of comparative advantage implies that a country can always trade successfully in some commodity even if its firms are inefficient (or burdened with environmental taxes or regulations)". In the view of these authors, the fundaments of national competitiveness are founded on the efficiency with which resources are allocated and used at the micro level and it is at this level that the consequences of regulation should be investigated. Mulatu et al (2001) also concluded in their meta-analysis

of studies exploring the environmental regulation-competitiveness links that this relationship ought to be investigated at disaggregated – sectoral and firm - levels rather than by national assessment. We should add that this view also seems to be endorsed by the Treasury and DTI assessment of national, regional and local productivity performance and its supply side drivers (DTI and HM Treasury, 2005).

. . . at sectoral level

2.8 At a sectoral level, competitiveness is defined as the ability of an industry or sector to sell cheaper or better quality goods and services in both local and international markets. Peterson (2003) defines industry level competitiveness as the ability of specific industries to compete for market share with businesses in the same sector located in other countries, which affects the location of production in other countries.

2.9 Many studies that we reviewed used trade (e.g. net exports) and investment flows as proxies or indicators of sectoral competitiveness (OECD 2003). Other studies – e.g. Jaffe and Palmer (1996) – sought to consider the drivers of trade competitiveness at the sectoral level such as total factor productivity and proxy measures of innovative capacity (e.g. R&D expenditure and patent applications).

2.10 The use of financial metrics is rare in the literature as a measure of sectoral competitiveness. A recent Carbon Trust paper (2004) assessed the impact of the EU Emissions Trading Scheme (ETS) on the competitiveness of a range of industries by assuming that this will be closely related to its impact on operating profit and used earnings before interest, tax, depreciation and amortisation (EBITDA) for this purpose.

2.11 Each of these measures has its problems, detractors and advocates. There is, for example, a whole literature devoted to the definition and measurement of total factor productivity and the usefulness or otherwise of EBITDA as a measure of sectoral or business performance. However, we think the literature suggests that the sector or industry or market provides a helpful organising framework within which to consider the dynamic interactions that need to be taken into account between competing businesses and between them and their customers when assessing the impact of environmental regulation on competitiveness. The sectoral work that has been done also confirms the approach at the national level that international competitiveness cannot be captured or understood by consideration of trade and investment flows alone.

2.12 Our review indicates that at both industry and firm level, research has been focused on the manufacturing sector and those industries that tend to be capital, resource and energy intensive. They are more likely than others to be disproportionately affected by environmental regulation and the most commonly researched ones are paper and pulp, cement, chemicals,

iron and steel, aluminium, electricity and oil (examples – Hitchens et al 2004, Carbon Trust 2004 and others).

. . . at firm or plant level

2.13 A recent paper for the International Energy Agency studying the impacts of the implementation of the EU Emissions Trading Scheme Directive (Reinaud 2005) defines competitiveness at firm level to be the firm's ability to maintain and/or expand market position based on its cost structure. An OECD paper (2003) stated that "competitiveness is primarily a matter of being able to produce goods that are either cheaper or better than those produced by other firms". Jenkins (1998) defines firm level competitiveness in a similar way – "a firm is competitive if it can produce products or services of a superior quality or at lower costs than its domestic and international competitors. It is therefore synonymous with a firms long-run profit performance and its ability to compensate its employees and provide superior returns to its owners".

2.14 As in the national and sectoral studies, the literature on the firm level impacts of environmental regulation uses a wide range of variables to capture competitiveness, as follows:

- Output
- Import or export performance, e.g. net exports
- Market shares
- Profitability
- Labour productivity or total factor productivity
- Productivity drivers – Innovative activity measures such as R& D expenditure or patent applications
- Cost of production
- Ability to absorb costs of compliance within costs of production or raise consumer prices as a consequence
- Plant location or locational decisions
- Plant survival

2.15 A distinct but related body of literature that looks into environmental strategies and management from the firm's perspective sometimes distinguishes between pollution control and pollution prevention innovation and related expenditures (Klassen (1996)).

2.16 The literature is thin in its use of financial metrics of firm level profitability. There are only a handful of studies that use stockholder wealth, return on capital or sales and price elasticities as indicators of profitability. One study (Helland and Matsuno 2003) uses a theoretical measure of firm rents – the ratio of market value of the firm to its replacement costs under the premise that, if firms earn no economic profit, the equity value of the firm should be equal to its replacement costs. Coeck and Verbeke (1997) use return on assets as a financial performance indicator linked to environmental strategy measures.

2.17 Some studies have drilled below the firm level and considered the impact of regulation on the competitiveness of individual plants. Gray and Shadbegian (1993), for example, analysed the impact of pollution regulation on the labour and total factor productivity of pulp and paper mills, oil refineries and steel mills. They found that there were significant differences in productivity between plants within the same sector – preparing the way for their assessment of differential effects between the plants from the same environmental regulation.

2.18 Analysis at the plant level is constrained by the limited amount of information that can be obtained on the costs and profitability of individual plants. But it lends itself particularly well to assessment of the impacts that regulation can have on the flows of mobile investment between countries or regions – an indicator of the extent to which the relative competitiveness of a location might have been affected by regulation. There is a body of work referred to in Jaffe et al (1995) that considered the effects of regulation on domestic plant location in the US.

Environmental regulation

2.19 The environmental regulations whose impact has been analysed in the literature are primarily drawn from the body of regulation relating to pollution control in its variety of forms. Some studies have considered pollution control as a whole (e.g. Buysse, Coeck & Verbeke (2000), Jaffe & Palmer (1996)) whilst others have been concerned with its particular focus – e.g. air quality regulations (Peterson (2003)), water quality regulations and solid waste or recycling.

2.20 Since a majority of the literature originates from the US, much of it tends to cover US based regulations, and many are based on those originating from the Environment Protection Agency (EPA). The European research seems to be mostly concerned with regulations originating from the EU such as REACH for the chemicals sector and the Emissions Trading Scheme.

2.21 There are two broad dimensions of regulation that have featured in the literature. The first is its stringency and the second its form.

Stringency of regulation

2.22 The stringency of a regulation has at least two elements – the standards that are set and the rigour of their implementation. Both have been captured by use of measures such as:

- pollution intensity or energy intensity as in Cole and Elliott (2003);
- the number of air and water pollution related inspections – Brunnermeier and Cohen (1999)); and/or
- regulatory cost information (as provided, for example, by the US Census Bureau's Pollution Abatement Costs and Expenditures (PACE) Survey).

2.23 The plant level study by Gray and Shadbegian (1993) used the PACE survey and combined the EPA's Compliance Data system and its Permit Compliance System to produce an overall enforcement measure (termed compliance status). Porter and Esty (2001) also derived a composite measure to reflect the stringency of national environmental regulation but theirs was more complex – embracing stringency of the standards, strictness of enforcement, quality of the environmental institutions – but could only be applied at national levels.

2.24 Finally, we should note that there is some concern reflected in the literature (Joshi et al 2004) about the 'hidden costs of regulation'. These refer to the effect of regulation on firms' costs by imposing constraints on production processes, altering raw material compositions, input proportions and energy use in ways that don't get acknowledged in accounting systems as regulation related. Joshi et al show that, for the steel industry, a $1 increase in visible costs is associated with a total increase at the margin of $10-11 – suggesting a very substantial under-estimate of the direct costs of regulation if reliance is placed only on accounted compliance costs. However, it may also be the case that predicted costs can be overstated and higher than actual costs (see the Stockholm Environment Institute study (1999) which found this to be the case across the five case study regulations it examined).

Form of regulation

2.25 Jaffe et al (1995) point out that keeping "constant the *stringency* of environmental standards, the *form* these rules take can potentially affect business location" or (as Wagner (2003) adds) competitiveness in general. If this is the case, then a real hindrance to understanding the nature of the relationship between regulation and competitiveness will be posed by the difficulties that seem to be associated with defining regulatory forms in ways that can be modelled.

2.26 There is a substantial amount of discussion in the literature about the differential benefits of different regulatory forms (see the OECD review, 2003) and there has been a range of studies that have focused on specific policy instruments – emissions trading (Reinaud 2005, Carbon Trust 2004, Peterson 2004), tradable permits (Johnstone 1998), Best Available Techniques (BAT) (Hitchens 2004) and environmental taxes (OECD 2003).

2.27 But, our review revealed that there is very limited empirical evidence on the influence that the form of regulation could have on competitiveness. We found just one study that looked at this question (Majumdar and Marcus, 2000). The measure of regulatory form they used was to classify environmental expenditures into two categories – flexible and inflexible. Air and water pollution control, for example, was classified as inflexible on the grounds that the regulation pursued "a deliberate technology forcing strategy". In the case of air pollution, firms have been subject to stringent best available control technology and lowest achievable emission rate standards.

2.28 Jaffe and Stavins (1994) analysed the effects of different environmental policy instruments on the diffusion of new technology (a driver of competitiveness) by estimating the economic penalty that firms reveal to be associated with violation of standards (performance or technology standards) or payment of emission taxes. They pointed out that, whilst theory supports the notion that market-based approaches provide the most effective long term incentives for invention, innovation and diffusion, there is a paucity of empirical evidence to substantiate the theoretical claim. Over ten years later, empirical analysis along these lines still seems to be limited.

Concluding observations

2.29 Following our review of the literature on the appropriate definitions to use in exploring the relationship between international competitiveness and environmental regulation, we agree with Jaffe et al (1995) (as summarised in the OECD review, 2003) that effective and practical tests of the relationship are likely to involve consideration of the following:

- The effects on productivity levels and growth induced by regulations of different stringency;
- Changes in net exports of goods and services subject to more or less stringent regulations (as measured in physical or cost terms); and
- Shifts in the patterns of investment flows and the location of production of pollution intensive goods and services away from locations (countries or regions) with the most stringent regulations.

2.30 There are two major caveats that we think should be taken into account when reviewing the outcome of tests such as these.

- First, the form of regulation may be as important as its stringency in determining the nature of the relationship. Even though this is an under-developed area in the literature, what evidence there is - and theoretical considerations - suggest that regulatory form needs to be taken into account.

- Second, the above tests do not make any allowance for macroeconomic adjustments through the exchange rate and real wages and, hence, any competitiveness impact and associated structural adjustment they might imply could be overstated especially in the longer term.

3 Evidence on the relationship between environmental regulation and competitiveness

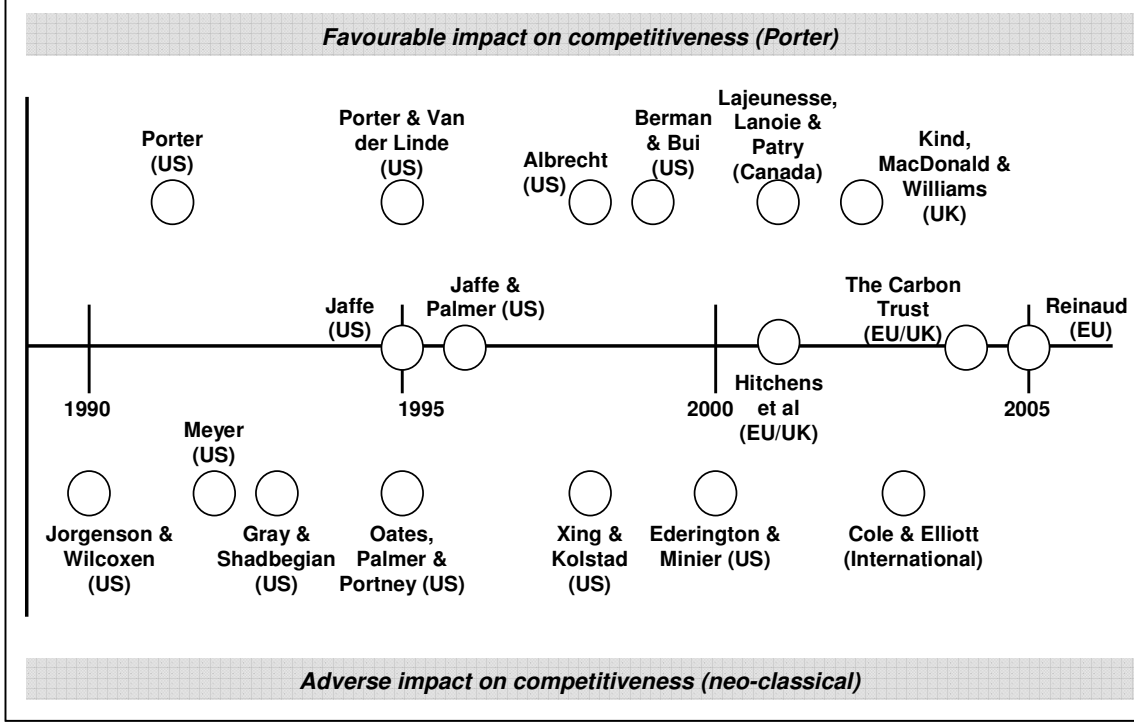
Nature and evolution of the debate

3.1 The debate on the relationship between environmental regulation and competitiveness is summarised by Wagner (2003) as follows:

> Porter (Porter, 1991 and Porter and van der Linde, 1995) "proposed and subsequently elaborated that stringent environmental regulation (under the condition that it is efficient) can lead to win-win situations in which social welfare as well as the private benefits of firms operating under such regulation can be increased. . . . One important reason for net benefits of stringent regulation at the firm level which is often cited by Porter and supporting colleagues is that such regulation can induce innovatory activities which increase their competitiveness. Opponents of the Porter hypothesis criticise its hidden assumption that firms systematically overlook opportunities for (voluntarily) improving their environmental performance that would also increase their competitiveness. Metaphorically, they argue that it is impossible to find a 10-Dollar bill on the ground because, if it was there, somebody else would have picked it up already." (Wagner, 2003).

3.2 This is not just an academic debate between neoclassical and more dynamic traditions of economic thought. It reflects political concern on the two sides of the Atlantic about the extent and quality of environmental regulations and their effect on competitiveness. The evolution of the literature is briefly explained in Annex D and summarised in Figure 3.1 by reference to some of the key contributions over the period from 1990.

Figure 3.1: Evolution of the debate on the effect of environmental regulation on competitiveness



3.3 In fact, concern about the trade off between environmental regulation and competitiveness was triggered earlier in the USA following the establishment of the Environmental Protection Agency (EPA) in 1970 and the introduction of the Clean Air Act. But, it was in 1991 that Porter (1991) made the clearest and highest profile break with the neo-classical economic framework in which the debate had been largely conducted. He suggested that, by abandoning some of the assumptions of the framework (notably, that all firms operated efficiently), it was possible to envisage that more stringent environmental regulations could be met at the same time as improving competitiveness primarily through innovation offsets – a conclusion that he and others confirmed from examples of corporate experience.

3.4 With two opposing camps becoming established, Jaffe et al (1995) entered the field with a comprehensive review article that occupied the middle ground by suggesting that "the truth regarding the relationship between environmental protection and international competitiveness lies between the two extremes (neoclassical and Porter) of the current debate". Thereafter, the literature broke into a number of different strands of exploration each concerned in its own way with identifying the circumstances in which (increasingly stringent) regulation might lead to adverse or favourable effects on competitiveness. It included more "bottom-up" microeconomic approaches to the development of both theory and evidence.

3.5 The prevalence and clear evolution of US literature on the environment-competitiveness debate has not been matched in the EU or UK, where until recently there was a paucity of literature and a much less structured argumentation process. A study by Hall and Soskice (2001) provides a useful background on the institutional foundations of competitiveness and the way that this affected the debate about the impact of regulation in Europe. These foundations still vary to a large degree in Europe and, consequently, the EU Member States provide different responses to the potential challenges posed for international competitiveness by regulation.

3.6 While the US EPA introduced regulations to achieve environmental outcomes from the 1970s, it was only in 1986 that the Single European Act introduced environmental policy into the catalogue of Community policies. Research by AEA/Metroeconomica (2004) observes that, in terms of air pollution, whilst "the US standards have been in place for many years – many of the EC limits have emerged in recent years with the Air Quality Framework Directive (1996) and the four Daughter Directives". The launch of the EU Emissions Trading Scheme prompted a focus on the environment-competitiveness debate as reflected in the work of the Carbon Trust (2004) and Reinaud (2005) on the impact of the Scheme.

3.7 In the UK, control of air, water and land pollution was not harmonised until the Environmental Protection Act 1990. The concept of Integrated Pollution Control, as it was known in the 1990s, developed with EU policy to become Integrated Pollution Prevention and Control, with the addition highlighting the shift away from emission control measures

towards pollution prevention. This shift was further accentuated in the UK by its Climate Change Programme, which was published in 2000 and reviewed in 2004. It includes a variety of market-based measures seeking to provide incentives to businesses to find cost-effective ways to reduce emissions, including the Climate Change Levy and Climate Change Arrangements. The increased policy focus on environmental protection led to an increase in the volume of regulations in the UK and contributed to the recent growth in studies of their impact on both competitiveness and environmental outcomes (Hitchens 2001, AEA/Cambridge Econometrics 2003, Carbon Trust 2004).

The mechanisms by which regulation can affect competitiveness

3.8 Environmental regulations can have an effect on competitiveness through the mechanisms depicted in a stylised fashion in Figure 3.2 - operating at different levels and revealed in different ways.

- They are shown in the diagram to exercise their direct influence on businesses and their establishments or plants (i.e. at the microeconomic level). The nature of the influence will be determined in part by the current efficiency of the businesses in, for example, their use of energy, their market power (i.e. the extent to which they can pass on to the consumer any increase in costs associated with the regulations) and their ability to respond to the regulations through technological change.

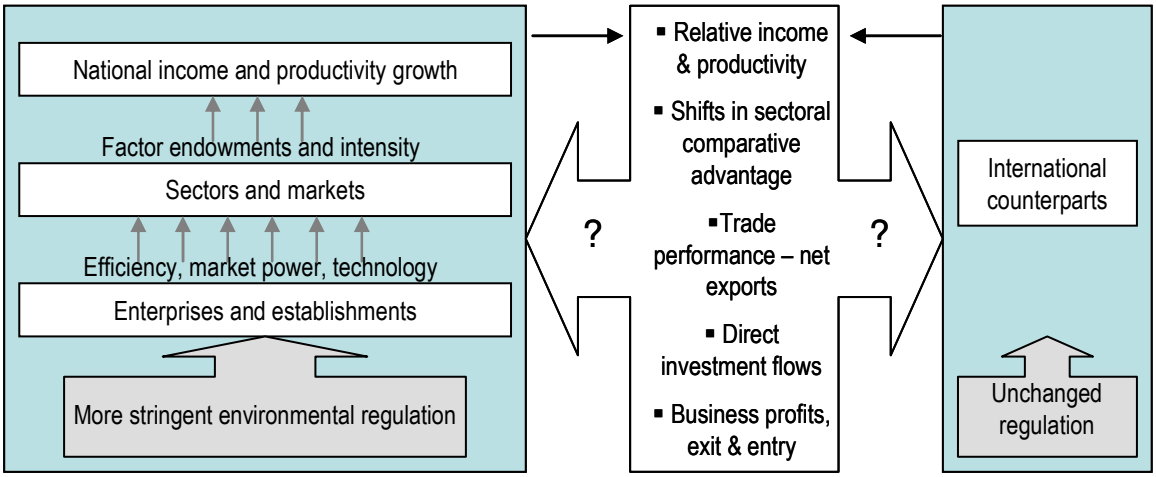
- The effects at this micro level will be manifest at a higher level of aggregation – at sectoral or market levels. The balance of the effects in terms of inter-sectoral patterns of output and productivity is likely to be influenced by the degree to which an economy is intensive in the use of the factors or resources that are the subject of the regulations (e.g. energy intensity) and the extent to which it is endowed with these resources (i.e. its comparative advantage).

- In turn, the sectoral consequences of the regulations will be translated into national income and productivity growth through a complexity of both direct and indirect effects which will include the ways in which factor prices and exchange rates adjust to the changes brought about by more stringent environmental regulations.

3.9 Figure 3.2 also suggests (in its central column) the manner in which these various levels of adjustment to the regulations will be revealed in the competitiveness of the economy in question relative to its international counterparts. The net effects will be seen in the economy's relative income and productivity growth, shifts in its comparative advantage, changes in its trade performance (as measured, for example, in its net exports), the patterns of outward and inward direct investment flows, and changes in business performance, plant survival rates and new entrant and start-up rates. These effects are likely to be greater where

the international counterparts have not experienced the same increase in regulatory stringency.

Figure 3.2: The mechanisms by which the effects of regulation on competitiveness work through and are revealed



3.10 After over a decade of debate, the literature on the impact of environmental regulation and competitiveness has understandably shifted in terms of focus and method. From early general equilibrium models dealing with the debate at a macro level (Jorgenson et al 1990, Meyer 1992), increased use was made of econometric and trade models to perform sectoral and, where data quality allowed, firm-level analysis. Given the concerns articulated by Krugman (1994) and Wagner (2003) and rehearsed in the previous chapter about the concept of competitiveness at a macro level, this shift has been integral in improving and maintaining the robustness of research and the wider debate. Data quality is, as we have found, one factor that still troubles some studies attempting to look at the relationship at the micro level.

3.11 In this chapter of our report[1] we provide a general review of the evidence base organised along the following lines:

- Effects of regulation on growth and productivity at the macro level;
- Export and other trade implications arising from regulation;
- Changes in investment flows and industry location induced by more stringent regulations; and
- Influences of regulation on the performance of sectors and/or businesses.

[1] Annex C provides a more detailed account of the methods of analysis that have been used and the estimates of impact they have generated.

3.12 Evolution also occurred in terms of incorporating the form of regulations and its role in modelling studies. While some early papers lack detail on the regulations or regulation proxies used in modelling, development of environmental policy has led some authors to incorporate regulation in modelling by way of a proxy for regulatory stringency (Harris, Konya & Matayas 2000, Cole & Elliott 2003). A further influence on more recent literature has been the changing form of the regulations themselves which has seen a progression from command and control techniques towards market based instruments and voluntary measures. This has prompted discussions of regulatory impact to concentrate increasingly on specific types of regulation and on the influence of regulatory form (Johnstone 1998, OECD 2003, Carbon Trust 2004, Speck 2005).We consider this aspect of the debate in the fourth chapter of the report.

Effects of regulation on growth and productivity – a macro perspective

General equilibrium analysis

3.13 General equilibrium studies seek to understand the way in which the shock of new or more stringent regulations works through consequent interactions in the national economy in which they have been introduced and, thus, into their effects on its international competitiveness. This is difficult to do and it is no surprise that few such studies were uncovered by our review. Their conclusions are generally that the effects are negative but not necessarily significantly so.

- Jorgenson and Wilcoxen (2001) found that, over the period 1974-1985, the combined effect of mandatory pollution abatement costs and investment as well as compliance with standards was to reduce the average growth rate of real GNP in the US by 0.2 percentage points. This was primarily because of the capital investment required to meet the regulations.

- Peterson (2003) considered the effects of the European Emission Trading System (ETS) by using the Dynamic Applied Regional Trade (DART) general equilibrium model. The study concluded that, on a business as usual scenario, the overall effect of the EU ETS on the EU was negative to a negligible extent with the sectors suffering a loss of output and exports being, as expected, the energy and energy intensive sectors. However, if it was assumed that countries outside the EU were to reach their Kyoto targets by means of a unilateral carbon dioxide tax, there would be resultant gains for the non-energy sectors in the EU and for the EU as a whole.

- The Carbon Trust (2005) explored the macroeconomic effects of the EU ETS by running the energy price increases it estimated to be induced by the Scheme through a general equilibrium model (Oxford Economic Forecasting - OEF). This generated significant adverse effects on national gross value added.

Macro-econometric studies

3.14 The Carbon Trust study is of particular interest because it contrasted the general equilibrium modelling results with those generated by a macro-econometric model (Cambridge Econometrics - CE). The two approaches projected carbon delivery of similar volumes of reduced emissions for the same package of regulations. But, the results were quite different in terms of economic impacts – see the box for an account of the extent of the difference.

3.15 The Carbon Trust suggests that two factors might explain the differences in the modelling results:

- **Revenue neutrality:** In the CE model, revenues raised by the instruments are returned to business through reductions in other taxes (e.g. NICs) – i.e. revenue neutrality is assumed. The OEF model does not include any explicit allowance for use of the revenues raised.
- **Announcement effects:** The CE model builds in an announcement effect that helps to reduce energy costs through anticipatory investments. OEF introduce a rate of return increase that promotes investment in specific sectors but only under one of the modelled scenarios. This may explain why the differences between the models are less pronounced in this scenario.

> In terms of economic impacts however, the results are quite different. Both analyse their economic results in terms of the gross impacts of the different packages on the Gross Value Added (GVA) of the different major sectors, but predict very different impacts of higher prices and structural changes to the packages. In the OEF model, CO_2 mitigation generally involves a trade off between carbon reduction and economic productions, whereas the CE model does not. For example, in 2010, the OEF model produces a loss in GVA of 0.3% in our high scenario an 0.1% in the base (low price) scenario, whilst the CE model predicts essentially no impact on GVA (0.01% loss in the low price scenario, and 0.01% gain in the comparable high price scenario). The losses in the OEF model are a bit more than twice as high when measured at market prices, or when the scenario is extended (with rising EU ETS prices) to 2020.

3.16 The Carbon Trust is commissioning further work to explore the different outcomes from the models. This will be particularly important in establishing what conditions and/or policy measures need to be in place to offset the reductions in economic growth that the general equilibrium modelling generally seems to suggest may be associated with the introduction of (increasingly stringent) environmental regulations.

3.17 As the work of the Carbon Trust shows, there is the potential to explore the competitiveness-environmental outcome trade-off through econometric modelling at national level. This approach has also been adopted to explore the trade-off as revealed through inter-regional growth performance (e.g. between the states of the US).

3.18 Thus, Meyer (1992, 1993) studied whether US states with stringent environmental regulations performed poorly compared with those with more lax standards and found that the "pursuit of environmental quality does not hinder economic growth and development" and did not find any statistically significant relationship between environmentalism and economic prosperity.

However, Jaffe et al (1995) point out that this may simply be because of 'missing variables' – "his approach does not control for factors other than the stringency of a state's environmental law that could affect the state's economic performance". As a consequence, the analysis does not allow for the reverse causation – i.e. that states with poor performance and prospects might be reluctant to increase the stringency of their environmental regulations.

3.19 Moreover, there is also the difficulty of disentangling the effects of regulation from the other influences on competitiveness, especially when they are marginal. Stewart (1993) reported, from a review of a wide range of studies, that regulation was not a dominant factor in determining international competitiveness. However, the study drew the conclusion that empirical studies on the impact of regulation on competitiveness were broadly consistent in showing that national differences in environmental regulation had important effects at the margin in the case of a relatively few 'dirty' industries.

International comparisons

3.20 If it is the case, as the general equilibrium and econometric studies suggest, that (increasingly stringent) environmental regulations are unlikely to increase and may adversely affect competitiveness outcomes, why is it that international comparisons of environmental and economic performance rankings are positive? Porter and Esty (2001) make such comparisons a central part of their argument by using the Global Competitiveness Report to derive an international comparative current competitiveness index (CCI) which they compared with two other indices – the environmental regulatory regime index (ERRI) and the economic and legal context index (ELCI) – through a series of bilateral regressions. Their findings indicate that many nations scoring well on the competitiveness index also had strong environmental performance scores.

3.21 The same correlation analysis was updated and reproduced in the Pilot 2006 Environmental Performance Index (2006). Figure 3.3 is the graphical depiction provided in that study of the positive relationship between environmental and economic performance.

3.22 The Carbon Trust (2005) provides a graph of international comparisons (see Figure 3.4) from which the conclusion can be derived that countries with 10% higher energy prices consume about 10% less energy. This suggests that rising energy prices (by regulation or other means) do not lead to increased national spend on energy and, therefore, will not affect national competitiveness through this particular effect.

3.23 However, it is one thing to demonstrate that relationships such as those depicted in Figures 3.3 and 3.4 hold, but quite another to argue that increasingly stringent environmental regulation brings about improved economic performance. It may be that the latter gives rise to environmental concerns and prompts regulation or it may be that other factors are at work

that bring about improvements in both sets of outcomes. In other words, there could be a problem posed by 'missing variables' and a difficulty, therefore, in holding other things constant in order to identify the direction and extent of the effect of different regulatory regimes on competitiveness.

Figure 3.3: International comparison of the relationship between environmental performance and GDP per capita

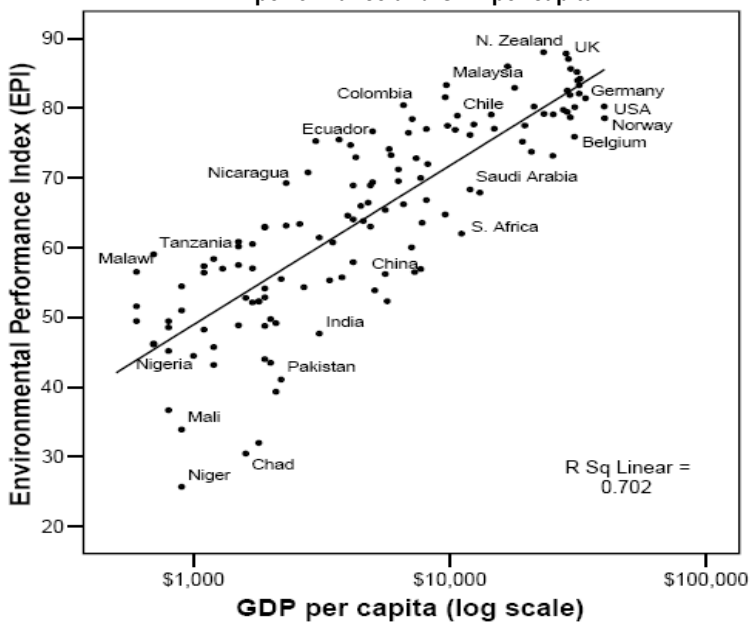
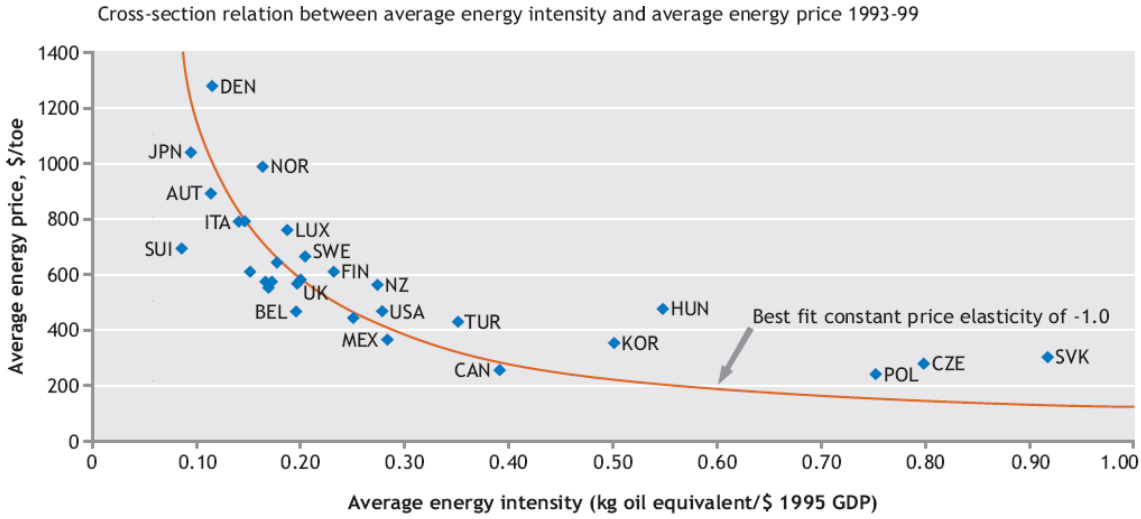


Figure 3.4: Relationship of energy price to energy intensity in different countries



Source: World Bank online database (www.worldbank.org/data/); Newbury (2003) 'Sectoral dimensions of sustainable development: energy and transport', Economic Survey of Europe 2003, No.2, Chapter 3, 73-93.

Trade effects of regulation

3.24 There is a rich vein in the literature devoted to the potential impact of regulation on the patterns of trade based on theories of comparative advantage. The findings are well

summarised in Jaffe et al (1995) and more recently by Mulatu, Florax and Withagen (2001). The former observed that, whether regulatory stringency was qualitatively measured (as in Tobey, 1990) or represented by environmental control costs, stringency was not a statistically significant determinant of net exports. However, they found from the evidence that trade competitiveness in pollution intensive ('dirty') industries was adversely associated to some degree with stringency of environmental regulation. Even so, the effect was thought to be small and "furthermore, it is by no means clear that the changes in trade patterns were caused by increasingly strict environmental regulations in developed countries".

3.25 The marginal effect of regulation on competitiveness was confirmed in Mulatu et al (2001) who concluded that the available evidence was uniform in suggesting that "the costs imposed by tighter pollution regulation may not be a major determinant of trade patterns". Whilst they pointed out that recent studies had occasionally found a negative correlation between trade and environmental stringency, they conceded that the findings were not particularly robust and suffered from the problem of missing variables.

3.26 They sought to rectify this by presenting new empirical evidence that identified the variables that had to be considered alongside regulatory stringency in order to understand the conditions under which it might adversely affect competitiveness. The evidence was based on environmental regulation compliance costs and the export performance of manufacturing industries in Germany, Netherlands and the US. Its conclusions were as follows:

- Sectoral variation in pollution intensity and the extent to which industries are resource based are necessary but not sufficient conditions for explaining the industry-by-industry and country-by-country variation in the observed effects of environmental policy on international trade.

- It is necessary also to take into account the factor intensity of the different industries and the relative factor abundance of countries. Thus, for a country in which a specific production factor is relatively scarce and an industry intensively uses this factor, then even a modestly stringent environmental regulation will induce a decline in exports (as in textiles, wood and fabricated metals in all three countries – except for the latter in Germany). However, industries that are intensive in production factors that are relatively abundant in the countries concerned show resilient export performance even though the environmental regulations are relatively stringent. They found this to be the case in the food, chemicals and non-metallic minerals industries in all three countries.

- Given the lack of clarity in the relationship between regulation and trade shown in the literature but the importance of the issue from a policy perspective, further research should not be focused on the stringency of environmental regulation in isolation but on the latter in combination with an assessment of relative factor intensity of industries and the factor abundance of countries.

3.27 A similar conclusion was suggested by the work of Cole and Elliott (2003) who found no evidence that proxies of environmental regulation stringency were significant determinants of 'dirty' net exports at international levels. But, they did find that net exports from the steel and chemicals industries were highest in capital-abundant countries while net exports of the non-ferrous metal and paper sectors were highest in countries with the largest endowments of minerals and forestry respectively. These findings may suggest that results on the impact of regulation are influenced by relative factor endowments and the intensity with which the factors are used.

Regulation effects on investment flows and location

3.28 There is a related strand in the literature that considers the effect of the relative stringency of regulation on the patterns of direct investment flows and the location of industries between countries and regions. The 'pollution haven' hypothesis is based on the notion that developing countries with less stringent environmental laws will be a more attractive location for new investments by pollution intensive or 'dirty' industries and the 'industrial flight' argument is that these industries are driven out of locations in developed countries as the stringency of their environmental regulations increase.

3.29 Again, Jaffe et al (1995) provide a review of the available evidence on direct foreign investment and domestic plant location decisions. They find neither source of evidence persuasive of the pollution haven or industrial flight hypotheses – "overall, the evidence of industrial flight to developing countries is weak at best" and "large differences in the stringency of environmental regulations among states had no effect on the locations of most new plants; but the locations of new branch plants of large multi-plant companies in pollution intensive industries were found to be somewhat sensitive to differences in pollution regulations".

3.30 Studies carried out since the Jaffe et al review generally confirm their conclusions in that it has proved difficult to identify a significant regulatory effect amongst the many other factors likely to influence the changing patterns of foreign direct investment flows.

- Smarzynska and Wei (2001) try to tackle the problems they found in the many tests that had been carried out of the pollution haven hypothesis by carrying out their own analysis using firm level data on investment projects in 24 transition economies. They used three different measures of environmental regulation and found no evidence for the pollution haven argument with two of them and only modest support using the third (reductions in emissions).

- The same conclusion emerged from a study of inward investment flows into Brazil and Mexico (Cole and Elliott, 2005) which found that they were characterised by high pollution, high capital and low skilled labour intensity and that the latter two factors were

far more important than 'pollution haven' effects. The analysis by Brunnermeier and Levinson (2004) confirms that other factors are likely to be more significant determinants of international location and direct investment decisions - factors such as the availability of infrastructure, agglomeration economies and access to large consumer markets. The study of the influence of air pollution regulations carried out by AEA Metroeconomica found that "it is extremely difficult to assess the impact of air pollutions on relocation from the other factors that determine location decisions."

3.31 These conclusions are still, of course, consistent with increasingly stringent regulations being significant at the margin.

3.32 Like the studies of trade flows, the evidence on investment patterns suggests that their determinants are complex and that the stringency of regulations must be regarded as one amongst a variety of influences at work – with more or less significance depending on other conditions.

Effects of regulation at sector, firm and/or plant level

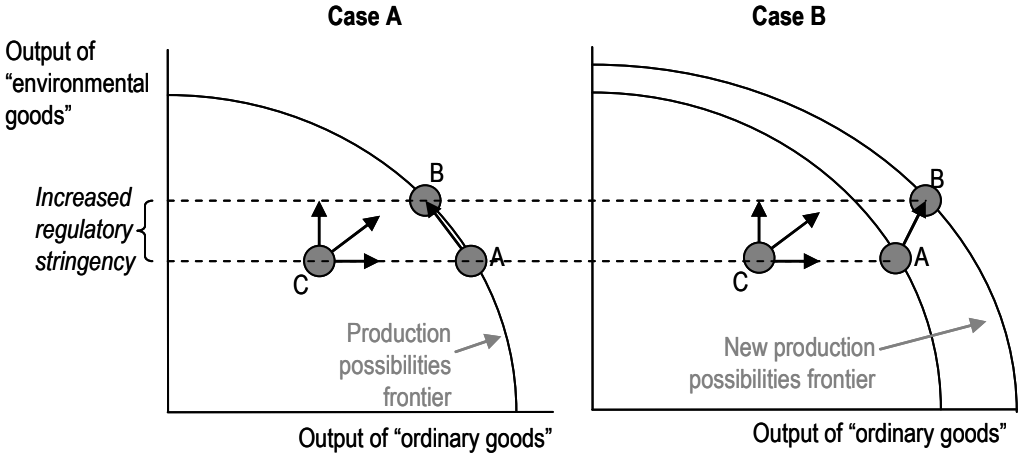
3.33 As noted earlier in this chapter (see Figure 3.2), the introduction of (more stringent) environmental regulation will exercise its most direct influence on competitiveness at the level of businesses and their establishments or plants. There could be important knock-on effects through the markets and economies in which the businesses operate and these may be more significant in a long term, general equilibrium sense at the level of the economy as a whole. But, the first "shock" of more stringent environmental regulation will be felt by the businesses concerned. How they respond will materially affect the degree and nature of adjustments that the rest of the economy will have to make.

3.34 Porter (1991), Porter and van der Linde (1995) and others who make the case that more stringent environmental regulation can induce beneficial competitiveness effects often support it by case study evidence of just such an effect – usually examples of regulations prompting innovation that had commercial as well as environmental pay-offs. As we have demonstrated previously in this chapter, the evidence from trade, investment and macro analyses is not so supportive. These analyses suggest that the strength or even the direction of the competitiveness effect may be something to do with the different sectoral circumstances in which the businesses in question operate and their different characteristics.

3.35 Before we consider the evidence on this question, we borrow from and, to some extent, develop the theoretical considerations in DeCanio (1997) to suggest a way of categorising the business and market characteristics most likely to influence the competitive response to increasingly stringent environmental regulation . We use DeCanio's work because we think it provides a helpful way of depicting the different responses of business to environmental regulation depending on where they are located with respect to the production possibilities

frontier between the production of "environmental goods" (like reduced carbon or CFC emissions) and "ordinary goods" (successfully traded "ordinary" goods and services) – see Figure 3.5. Increased stringency of environmental regulation would be depicted in this formulation as requiring an increase in the output of the environmental goods.

Figure 3.5: Production possibilities with increased environmental regulatory stringency



Source: Adapted from DeCanio (1997)

3.36 The figure suggests a possible starting point (A) where businesses are efficient and are located on the frontier that optimises between their output of ordinary traded goods and the required output of environmental goods (as determined by legal and other demands). In these circumstances, increased regulatory stringency would require increased output of environmental goods (e.g. more reductions in carbon emissions) and could only be achieved, if nothing else changed, by a reduction in the output of ordinary goods (as shown in Case A by the movement to point (B)). This represents what has been described earlier in this report as the neo-classical conclusion that there is a straight trade-off between ordinary and environmental goods and a loss of competitiveness as shown in the reduction of the output of ordinary traded goods. As a short-hand, we will call this the 'productivity penalty' effect.

3.37 However, Case B in Figure 3.5 presents a situation in which the economy is not static but experiences technological progress represented as an outward shift of the production possibilities frontier. In this case, if the firm at the starting position (A) has the capacity to take advantage of the opportunity presented by the technological change in production possibilities, it can meet the more stringent requirement for increased production of the environmental goods at the same time as increasing production of the ordinary traded goods – by moving to point (B) in Case B. We will refer to this as the 'induced innovation' effect. It should be noted that there may still be an opportunity cost here because the firm could have taken the opportunity presented by technical progress to further increase the output of the ordinary goods with no increase in the output of the environmental goods. The extent to

which this will happen will depend, as DeCanio points out, on the degree to which both sets of goods are complementary or substitutes.

3.38 The figure also presents the situation of a business that lies within the production possibilities frontier – i.e. at position (C) in both Case A and B. This starting point reflects one of less than full efficiency but one in which the firm meets the prevailing requirement for the output of the environmental goods. From this point, the firm could move in a wide variety of directions to get closer to the frontier and still meet the environmental output requirement. With an increase in the stringency of the latter, the firm could meet the new requirement by cutting back its output of ordinary goods or, at least, not increasing them. However, because it lies within the frontier, it also has the possibility of meeting the increased stringency for the output of the environmental goods by increasing the output of its ordinary traded goods as well. It will clearly be to its advantage to look for complementarity between the two types of goods and seek to increase the output of both. We will call this the 'efficiency gain' effect and anticipate that it will be more likely to arise in highly competitive markets and where the costs of compliance are relatively low.

3.39 In summary, Figure 3.5 suggests responses to increased stringency of environmental regulation which have the following three distinctive effects:

- **Productivity penalty**: The increased output of environmental goods is achieved only by a reduction in the output of the traded goods and services of the sectors, firms and plants affected;

- **Induced innovation**: The response is to achieve increased outputs of both sets of goods through technological change in the products produced and/or the processes used by the firms; and

- **Efficiency gain:** Firms are induced to increase their efficiency by the regulation and achieve increases in the outputs of both sets of goods.

3.40 The question that follows is whether the literature provides evidence on the extent to which these circumstances are likely to prevail. There is a substantial body of literature that considers the microeconomic evidence on this. It falls into three broad categories – studies that look across sectors to find evidence of the relationship, those that consider specific sectors and those focused on particular businesses.

Inter-sectoral studies

3.41 Gray and Shadbegian (1993 and 1994) merged US plant level input and output data with plant level data from the PACE surveys and estimated equations for productivity as a function of pollution control expenditures. In the specification in their 1994 work that was robust to the

measurement error problems in their first analysis, they found evidence of a productivity penalty associated with increased control costs. The penalty was discerned in both level and growth terms – i.e. plants with higher and growing compliance costs tend to have lower productivity levels and slower productivity growth rates.

3.42 A productivity penalty effect was also discerned by Lajeunesse et al (2001) from their analysis of regulatory stringency and total factor productivity across manufacturing sectors in Quebec. However, when lagged effects were allowed for in the regulation variable, the negative effects on productivity growth in the short term translated into positive effects over the longer term (four years). This effect was replicated at individual sectoral level but only for the less polluting sectors and for the sectors most exposed to competition. This is consistent with the view that efficiency gains are more likely in competitive markets and where compliance costs are low.

3.43 A modest induced innovation effect was found in a study by Cohen (1999) that used US based industry data in the manufacturing sector from 1983 to 1992 to show how industries responded to changes in pollution abatement policies and regulatory enforcement through innovative activity, using patents as a proxy. The study found that increases in pollution abatement expenditures (regulatory pressures) were associated with a small but significant rise in environmental innovation.

3.44 Jaffe and Palmer (1994) explored the induced innovation effect by examining the PACE expenditure data, R&D spending data and patent data in a panel of industries between 1976 and 1989. They found some evidence that increases in PACE expenditures were associated with increases in R&D spending but no evidence that this increased spending produced greater innovation as measured by successful patent applications.

3.45 These findings were also supported by Hanel (2003) who considered the impact of innovation motivated by environmental concerns and government regulations on firm performance using a panel data of firms from the Statistics Canada Innovation survey. These firms launched new or improved products or processes in response to government regulation and/or environmental concerns. The study suggested that firms that pursued the reduction of environmental damage as one of their innovation objectives were more likely than other innovators to report that innovations improved their performance.

3.46 There is further evidence to suggest that, overall, firm characteristics matter with regard to the propensity for energy efficient investments as witnessed by their participation in energy saving programmes. Savageau (2004) confirmed the findings of DeCanio and Watkins (1998) that the characteristics of firms do matter in this regard. The strong positive significance of employee numbers is most likely due to the EPA's marketing effort aimed at recruiting large companies to the energy saving programme. The positive relationship between number of shares and dividend yield and participation could potentially be due to

pressure from shareholders for firms to be either environmentally responsible or be aggressively investing in all positive net present value opportunities. The coefficient on the Quick ratio was negative and implies that the more cash and inventories a firm has on hand, the less likely it will be to invest in efficiency improvements. All sectors (bar one) are negatively related to the probability of participation relative to the manufacturing sector. As Savageau points out, this could be due to the potential of increase efficiency savings for manufacturing firms that extend improvements beyond lighting (upgrading HVAC systems, more efficient generators, machines, and typically production facilities that operate on a 24 hour/day basis).

3.47 Overall, the inter-sectoral studies provide support for efficiency gain and induced innovation effects even though there may be productivity penalty effects in the short term, especially in competitive markets.

Sector specific studies

3.48 There have been a number of studies focused on specific sectors and some that considered particular pollution control instruments in terms of their effects on specific sectors.

3.49 Among the early studies on the impact of environmental regulation on industry productivity, Barbera and McConnell (1988) use data from five manufacturing industries (paper, chemicals, stone, clay and glass, iron and steel and non-ferrous metals – largely pollution intensive sectors) to model the impact of abatement requirements on industry costs and total factor productivity (TFP), by distinguishing between conventional inputs of labour, capital, energy and materials and abatement capital.

3.50 The study identifies two effects of the required abatement capital investment on TFP. First, the requirement to invest in abatement capital causes total costs of inputs to rise. Secondly, this requirement may affect the combination of conventional inputs and result in a resource reallocation within the firm. The authors adopt a translog production function and find that abatement requirements, including both direct and indirect effects, results in reductions in TFP in each of the five industries (i.e. a productivity penalty effect)[2].

3.51 Boyd and McCelland (1999) and Boyd and Pang (2000) employ data envelopment analysis to evaluate the potential at paper and glass plants for "win-win" improvements that increase productivity and reduce energy use or pollution. They suggest that the paper industry could reduce inputs and pollution without reducing productivity.

[2] However, the authors acknowledge that they did not take into account both the costs and benefits of environmental regulation (as also pointed out by others (see DeCanio 1999 and Telle and Larsson 2004)). Annex C explains this further

3.52 Berman and Bui (1999) found that the impact of regulation on oil refining was to induce about $3m abatement investment for the average refinery and an increase in stringency induced on average $5m abatement investment. The study concluded that, despite this increasing regulation and abatement activity in the South Coast region of the US, the refineries there showed increased productivity that was robust to changes in the model that was used (i.e. an efficiency gain or induced innovation effect). This was found to be particularly so when compared with refineries in other regions.

3.53 A study of the cement industry by Hitchens and Triebswetter (2004) investigated the impact of environmental regulation on the competitiveness of the European industry by analysing the results of a matched plant comparison between Germany, Spain and the UK. The study found that despite the fact that cement is a mass production commodity where cost competitiveness is likely to be critical, and Germany plants use costly abatement techniques, environmental regulation had no impact on their competitiveness.

3.54 On the other hand, an OECD study found a productivity penalty effect in the steel industry (OECD, 2003) where it was concluded, on the basis of a partial equilibrium model of the sector, that an OECD wide carbon tax would reduce steel production by 9% and world production by 2%. It would also prompt some substitution from the use of pig iron to more intensive use of scrap in basic oxygen furnace steelmaking. The consequent rise in scrap prices would weaken the competitiveness of scrap based electric arc furnace producers. The adverse effects of the regulation would be softened to the extent that increased costs could be passed on to consumers. This extent would be clearly dependent on the degree of market power, heterogeneity of the product and the degree to which the tax was unilaterally imposed by region or country.

3.55 The relevance of market power was highlighted in a study by Helland and Matsuno (2003) who investigated the impact of compliance costs on economic profit using changes in an industry level measure of environmental compliance costs produced by the US EPA. Whilst in general, the study found no relationship between increased compliance costs and higher economic profits, this relationship was found to hold for the largest firms. The authors concluded that the impact of more stringent regulation could be to increase entry barriers, reduce market competition and distribute wealth within industries.

3.56 The influence of market power is also considered in three studies of the impact of carbon emissions trading mechanisms – Convery (2003), Reinaud (2005) and the Carbon Trust (2004). The Convery work was a review of evidence that suggested that as many emitters as possible should be covered by the scheme to dilute market power and prevent a limited number of entities to influence the permit price. Reinaud found that market concentration, market power and the degree of market openness to non EU competitors affected the capacity

to reflect cost increases in product prices. The industry's ability to pass cost increases is critical – electricity was found to be the only sector likely to partially do so.

3.57 The study by Carbon Trust[3] analysed five energy intensive UK sectors that differ in their energy intensity and trade characteristics – electricity, cement, paper, steel and aluminium – to consider how they would be affected by the EU ETS. Its study concluded that, while within the electricity sector, a relatively low proportion of the cost increase is required to be passed through to prices to maintain pre-ETS profits, and cement and paper could also be only marginally affected by ETS, the aluminium sector would take a significant hit.

Studies of business behaviour and responses

3.58 The potentially positive influence of environment regulation on competitiveness is presented by Porter at firm as well as national level and is supported by studies such as the one by Gabel (1990) who looks at the failure of neoclassical theory to consider the imperfections of firms, i.e. organisational and information failures. Pollution control policies and regulation can enable and prompt identification of 'low hanging fruit' – opportunities for improved resource efficiency that offer win-win situations for the environment and firms. In other words, there is an efficiency gain effect or, to use Wagner's metaphor which we quoted earlier in this chapter, there is more than one 10 Dollar bill lying on the ground that nobody has already picked up.

3.59 Gabel points out that there is a lot of evidence for the kind of organisational failures that give rise to the conditions under which environmental policies can provide win-win solutions. Notably, firms must not be resource efficient, as social and private costs can only be reduced simultaneously from a position within the production possibility frontier. Win-win outcomes will be most likely when a firm is far from the efficiency frontier, when compliance costs are low and where shift to the frontier can be made cheaply.

3.60 DeCanio (1997) makes the same point about the extent to which businesses are often positioned well within the production possibility frontier by reviewing the empirical evidence on the 'efficiency gap' between the actual point of production and the frontier. This leads him to conclude that, for a wide range of sectors, the efficiency gap could be of the order of 14% - "realising even a fraction of these potential gains would outweigh the most pessimistic estimates of the cost of climate stabilisation strategy".

3.61 Schmutzler (2001) accepts the basic proposition that many firms may lie within the production possibilities frontier but asks why these firms refrain from cost-reducing innovations for so long but are prompted to innovate when more stringent regulations are introduced. He investigates this in a theoretical approach which turns on the different

[3] The Reinaud and Carbon Trust studies are considered and compared in more detail in Annex C.

incentives prevailing for firm managers who will tend to be more risk averse (i.e. have lower time preference rates) than their owners. The incentive problem that this represents may explain why cost-reducing innovations are not pursued by managers but it does not necessarily result in induced innovation from (increasingly stringent) environmental regulation. The degree to which this will occur will depend on the extent of differences in the rates of time preference between managers and owners and on the nature of the environmental regulation - "innovation offsets can only arise when policy is sufficiently flexible; a policy that targets only end-of-the-pipe technologies cannot be beneficial for the firm."

3.62 Schmutzler shares this conclusion with a number of other contributors to the debate. Thus, Jaffe, Newell and Stavins (2002) suggest that technology standards are particularly problematic – "under regulations that are targeted at technologies, as opposed to emission levels, no financial incentive exists for businesses to exceed control targets and the adoption of new technologies is discouraged". They report a number of studies which considered the influence on the competitiveness outcome from the form of regulation (including research and development subsidies as well as control-and-command and market based incentives) and from the competitive conditions in the markets in question that affect the incentives for innovation. The empirical evidence is generally consistent, they conclude, with the theoretical findings that market based instruments are likely to have significantly greater, positive impacts over time on the invention, innovation and diffusion of environmentally friendly technologies.

3.63 This conclusion supports the earlier observation by Porter and van der Linde (1995) that past environmental strategies might have had adverse effects on competitiveness by being focused on pollution control mechanisms which tend to be inefficient (especially when associated with prescribed technical solutions). But, they point out that these have been increasingly replaced by pollution prevention strategies and measures. These are much more likely to lend themselves to positive competitiveness outcomes because they prompt material substitution and other means to manage pollution emissions out of the production system which can have beneficial effects on productivity more generally.

3.64 So, this chapter ends in the same way as the previous chapter by referring to the influence that the form of regulation might have on competitiveness. Only this time, the theory and evidence seem to present us with one interesting, if not ironic, proposition. It is that a positive relationship between environmental regulation and competitiveness may be more likely to be achieved where the private sector is resource inefficient in its business and the public sector is resource efficient in its regulatory interventions. It is, perhaps, that counter-intuitive juxtaposition that triggered such an extensive debate in the literature.

3.65 However, as Jaffe et al (2002) observe, whilst the fact that firms engage in non-optimising behaviour creates a possibility for profit improvement from (increasingly stringent)

regulation, it does not suggest that "such improvements would be the norm, would be systematic or even likely". So, the question that is prompted is, '*what is it about the form of the regulation and/or the nature of inter-firm competition that will induce favourable competitiveness outcomes from regulation?*' We will explore the literature on the influence of regulatory form in the next chapter. On the second part of the question, we have to conclude that the literature does not as yet offer systematic and consistent theoretical and empirical evidence on the characteristics of competitive conditions that are more or less conducive to positive productivity outcomes from environmental regulation.

3.66 However, induced innovation and efficiency gain effects from regulation are clearly available – both theory and empirical evidence suggest that this is the case. The issue for the regulators is how to maximise the likelihood and extent of these effects from the way they design and implement the regulations at the same time as meeting their environmental objectives. The study by Coeck and Verbeke (1997), involving a survey of 450 of the most pollution intensive firms in the Belgian manufacturing sector, found there to be a symbiotic relationship between private and public sector environmental strategies. They found that the more pro-active (compared with reactive or anticipatory) a firm's environmental strategy, the more environmental regulation is likely to be effective and the key determinants of that will be the specific firm conditions under which the firm operates and the regulation is implemented:

- Shareholder pressures, perceived economic opportunities and the nature of national and sub-national regulatory pressures were found to be the key determinants of a proactive environmental strategy.

- Many firms had shifted from a reactive to anticipatory environmental strategies even though only a minority had adopted proactive strategies. This shift appears to have been motivated by a belief that prevention at the source leads to lower pollution abatement and compliance costs and the prospect for wider efficiency gains.

- Firms with a proactive environmental strategy perceived regulatory pressure as less of a constraint than firms with an anticipatory strategy, suggesting that a shift to green strategies may be induced through public-private sector partnership (with due regard to their different as well as shared perspectives on resource efficiency) rather than on environmental policy implemented through pollution and technology control measures).

Concluding observations

3.67 The literature reviewed in this chapter has often seemed like a debate in which the protagonists present deliberately opposed positions without looking for the common ground. The result is an apparent conflict or confusion of evidence to which the most appropriate response might be to say that 'the jury is still out'.

3.68 We are not persuaded that this is the case. Consider the evidence that we have rehearsed in this and the previous chapter:

- **Specification and measurement of key variables:** There are difficulties in specifying and measuring the relevant variables – the stringency of environmental regulation, the indicators of competitiveness and the way each of these should be expressed at national, sectoral and business levels.

- These problems have increasingly been resolved as it has become clearer what proposition is being addressed amongst the many posed by the debate. These propositions (and the definitions they use) have been tested in many ways:

  - Macroeconomic modelling of the effects on national income and productivity growth from more stringent environmental regulation as measured in physical terms (e.g. the number of air and water pollution related inspections) or costs (e.g. from the US Pollution Abatement Costs and Expenditures (PACE) survey;

  - Econometric analysis – both cross-sectional and longitudinal – of patterns and changes in the net exports of goods and services that are subject to more stringent regulation in one country compared with others;

  - Case study and econometric analysis of shifts in the patterns of investment flows and in the location of production of pollution intensive goods and services away from locations (countries or regions) with more stringent regulations;

  - Econometric analysis of changes in inter-sectoral productivity and innovation in response to more stringent regulation;

  - Bottom-up modelling and case studies of how specific sectors or firms respond to increased stringency of regulation.

- Such modelling suggests that regulations are unlikely to increase competitiveness (econometric models) and may adversely affect it (general equilibrium models). Jaffe et al (1995) provided a good service in this regard by disentangling and specifying the different sub-texts of the debate that deserved to be examined. Within the refined framework of analysis they provided, there has been a lot of work done to facilitate specification of indicators and their quantitative measurement in ways that have enabled international, cross-sectoral and business and plant analysis.

- There remain two variables that have proved difficult to nail down but are key in defining to what extent and under what conditions regulation exercises adverse or positive effects on competitiveness.

- **Forms of regulation:** There is little from the literature that can help us define or capture the form of regulation – especially, in terms of the way it gives flexibility for business responses at the same time as it achieves its environmental objectives.

- **Responses by business:** There is evidence on the resource inefficiency of businesses but it has proved difficult to express this and their willingness/capacity to adapt in indicators and measures that lend themselves to quantitative modelling

- **Macroeconomic effects of increased regulation:** The limited amount of general equilibrium and econometric modelling finds that increasingly stringent environmental regulation has a negative effect on economic growth. This may be due to the resource efficiency assumption on which they are based. Moreover, the adverse effect can, to varying degrees, be offset by:

  - **Revenue neutrality policies**: Increase or introduce reductions in corporate or personal taxation equivalent to the increase in cost associated with the imposition of environmental taxes or cost increasing controls.

  - **Level playing fields**: Negotiate for the extent and nature of regulation to be multilaterally agreed amongst competing nations and regions.

  - **Awareness and investment promotion:** Ensure that businesses are made aware of the regulations and prompt them (through advisory and grant support) to invest in improved operating practices.

- **Trade effects of regulation:** The evidence seems consistently to be that the costs imposed by tighter pollution regulation are not a major determinant of trade patterns even for those sectors most likely to be affected by such regulation. However, there is some evidence that regulatory stringency may exercise an influence once account has been taken of the factor intensity of the different industries and the relative factor abundance of countries. Thus, for a country in which a specific production factor is relatively scarce and in which an industry intensively uses this factor, then even a modestly stringent environmental regulation will induce a decline in exports.

- **Regulation effects on investment flows and location:** Like the studies of trade flows, the evidence on investment and locational patterns suggests that their determinants are complex and that the stringency of regulations must be regarded as one – and often a modest one - amongst a variety of influences at work with more or less significance depending on other conditions.

- **Effects of regulation at sector, firm or plant level:** Inter-sectoral studies tend to reveal that generally there is a modest productivity penalty associated with increased stringency of regulation. But, they also provide evidence of a countervailing innovation push that

can come from increased regulatory stringency – especially larger firms with a track-record of innovation. Sector specific studies find further evidence of induced innovation and efficiency gain effects that stringent regulation can prompt. They also suggest that the extent of market power and the ability to pass through increased costs to the consumer are critical in determining the extent to which regulation has adverse effects on business performance. Finally, firm specific studies also show that there are a good many businesses that are located within the production possibility frontier and for whom regulation creates the possibility for both increased productivity and reduced emissions. The question is how to make those possibilities more systematically available, identified and pursued through the design and implementation of the regulations.

4 The influence of regulatory form

Introduction

4.1 Economists have traditionally placed environmental policy instruments into two categories – those that provide firms with relatively less flexibility ('command and control') and those that provide firms with incentives to look for more effective ways of achieving the environmental objective ('market-based'). At least in theory, 'market based instruments' – mainly pollution taxes and tradable permits' are more effective than 'command-and control' instruments such as design standards. They are not only considered to be more cost-effective but also tend to provide dynamic incentives for technological innovation and diffusion.

4.2 Hence it is likely that the form of regulation will have as much influence on competitiveness as its stringency. Porter (1990, 1995) stated that *stringent* and *well-designed* regulations can trigger innovation that may partially, fully or more than fully offset the costs of regulatory compliance. Such 'innovation offsets' can also lead to absolute advantage over firms not subject to similar regulations in other countries. He suggested that properly crafted environmental regulation can serve at least six purposes:

- Regulation can signal firms about likely resource inefficiencies and potential technological improvements
- It focused on information gathering can raise corporate awareness
- It can reduce the uncertainty that investments to address the environment can be valuable
- It creates pressure that motivates innovation and progress
- It levels the transitional playing field – during the transition to innovation based solutions, regulation ensures that one firm cannot gain against another by avoiding environmental investments
- Regulation is required in case of incomplete offsets.

Instrument choice in environmental regulation: theory

4.3 Economists prior to Porter had examined some of the theoretical efficiency advantages that some forms of regulation have over others but such comparisons have resulted in little agreement or consensus.

4.4 Milliman and Prince (1988) used a simple model of pollution control to identify firm incentives that promote innovation, diffusion and optimal agency response under five forms

of regulation – direct controls, emissions subsidies, emissions taxes, free marketable permits, and auctioned marketable permits. They find that when policies are fixed over time, emissions taxes and auctioned permits provide the highest incentives while direct controls provide the lowest.

4.5 Jung et al (1996) used Milliman and Prince's basis framework for evaluating the incentive effects of policy instruments but assumed a heterogeneous industry of firms and modelled the 'market-level' incentive created by the instruments. Their results were similar to those of Milliman and Prince - auctioned permits provided the greatest incentive, followed by taxes and subsidies, free permits and performance standards.

4.6 On the other hand, Parry's (1998) theoretical framework concluded otherwise. He sought to identify the conditions under which there might be a substantially large R&D efficiency gain from using emission taxes over other policy instruments by developing a theoretical framework for analysis. The author's analysis suggests that the induced welfare gain is greater under an emissions tax than tradable emissions permits, but the importance of this depends crucially on the size of the potential innovation – the R&D efficiency gain under permits is around 90% or more of that under an emissions tax for innovations that reduce abatement costs by up to 10%. It is around 60-70% of that under the emissions tax for innovations that reduce abatement costs by 40%.

4.7 Different forms of market-based instruments may have very different effects in terms of incentives for innovators. Johnstone (1999) showed that while taxes and subsidies generally perform well, the effects of permit systems may differ. Auctioned tradable permits result in stronger dynamic incentives than grandfathered tradable permits. Under the former system, the innovating firm will pay lower permit prices if other firms adopt the innovation. Under a grandfathered allocation, the fall in permit prices would benefit buyers but would hurt the sellers. As the innovating firm would have already adopted the innovation, it would be a net seller and lose from the diffusion of abatement technology.

4.8 Models of regulatory form are not necessarily restricted to types of economic instruments. Coeck et al (1997) developed a management oriented conceptual framework for analysing the impact of environmental taxation on corporate social performance. The study stated that an environmental tax aimed at achieving pollution reduction and/or revenue generation and those that are considered as a legitimate instruments that do not jeopardise the international competitive position of the affected firms will result in 'virtuous' cycles of public policy actions and corporate strategy responses. On the other hand, environmental taxes aimed mainly at achieving revenue generation rather than pollution reduction and which are viewed by the business community as an illegitimate instrument of government policy, jeopardising the international competitiveness of firms, will result in a 'vicious' cycle of public policy actions and corporate strategy responses.

Effect of regulatory form on competitiveness

4.9 Our review suggests that there is not a great deal by way of empirical work on the different forms that regulation can take and the effects of their form of implementation on firm behaviour. Nevertheless, what little evidence there is suggests that economic instruments have had no major adverse effect on competitiveness.

Standards, taxes and tradable permits

4.10 Johnstone (1998) reviewed the evidence base on tradable permits as economic instruments, and within these, the different mechanisms of implementation, and their impact on industrial competitiveness and found that market based instruments provide better incentives for abatement technology and diffusion than control based rules. Hence they will have positive competitive effects by pushing firms along a technological trajectory that allows them to achieve environmental objectives at lower costs than those born by the firm in the first instance.

4.11 Wagner (2003) evaluated standards, taxes and certificates against a set of criteria (efficiency, dynamic incentive effects, structural policy and environmental effectiveness) and found that standards and permits scored highest with regard to environmental effectiveness. He noted that the dynamic incentives effects need to be taken into account too, as new and more efficient technologies for emissions standards depends on the instrument chosen.

4.12 Johnstone (1998) had also stated that, while it is relatively straightforward to understand the attractiveness of market based measures due to efficiency gains, their advantages were less clear when firms had to bear financial costs for residual emissions. Under an auctioned permit system, firms would bear the full costs of permit expenditure but would not reap the benefits associated with increased government revenue arising from permit sales. This is more the case for energy intensive firms (or those that are intensive in emissions being taxed or marketed) than those that use other factors of production.

4.13 While tradable permit systems could have a positive impact on competitiveness owing to the fact the abatement costs are equalised across firms, firms may be better off under a grandfathered system than an auction based system; individual firms may have pay for permits as well as abatement control under the latter whereas grandfathered permits are distributed freely to existing emitters on the basis of average consumption of energy.

4.14 The Carbon Trust (2004) study found similar results, when using one of their macroeconomic models to estimate the impact of EU ETS – the trade off between carbon reduction and economic production is much greater for energy intensive sectors than in non-energy intensive sectors. In an alternative model that assumes revenue neutrality, i.e. that revenues

raised by the instruments are returned to business via reductions in other taxes, the trade-off between carbon reduction and economic output disappears.

4.15 A study by ECOTEC (2001) explored whether taxes and charges have brought about the environmental benefits that those supporting taxation have claimed and whether the concerns regarding their impact on employment and competition are real. It highlighted that the major concern expressed in the design of levies is their effect on the competitive position of affected sectors, especially in international markets. This concern has resulted in the conservative design of environmental regulations and in particular, has led to a plethora of exemptions of polluters from the various levies because of the perceived danger to the competitive position. As a result, the impact of levies on competition and trade is generally negligible since the potential for such impacts is eliminated in the design.

4.16 An OECD study (2003) provided a framework for assessing the influence of environmental taxes on competitiveness. It concluded that the differences between environmental taxes and other instruments were not as stark and clear-cut as often was assumed in terms of their effect on competitiveness. However, it drew the important policy conclusion that, in terms of competitiveness, it will generally be preferable to deploy an environmental tax (or, equivalently, auctioned tradable permits) and use the revenue raised to reduce the rates of existing taxes on business than to allocate permits through non-revenue raising "grandfathering" procedures.

4.17 The study identified a number of strategies that could be adopted to mitigate adverse effects of environmental regulation on sectoral competitiveness as follows:

- Revenue recycling targeted on measures that would reduce business tax burdens;
- Sectoral exemptions or differentiated ecotax rates across sectors;
- Border tax adjustments – e.g. charging taxes on imports and rebating taxes on exports with regard to countries without the same ecotaxes; and/or
- International coordination to achieve a level playing field.

Voluntary Initiatives

4.18 Our review did not explore the theoretical models of voluntary approaches to pollution control and other environmental initiatives but interrogated the literature for their impact on competitiveness. There is limited but growing empirical evidence on the effects of voluntary economic instruments in environmental policy on competitiveness.

4.19 The US EPA's Voluntary 33/50 programme[4] triggered much research into the effectiveness of voluntary approaches in raising both environmental objectives and economic performance. Khanna and Damon (1998) examine the incentives for participating in the programme and the impact of the programme on toxic releases and economic performance of firms in the US Chemical industry. After taking into account firm-level characteristics, the authors found a statistically significant decline in toxic releases during the period when the programme was in operation. While the programme had a negative impact on the current return on investment for firms, it appeared to have a positive impact on their expected long run profitability.

4.20 The authors also noted that as far as participation decisions of firms were concerned, the desire for public recognition and goodwill drove firms to participate. Reductions in toxic releases before participation did not affect participation, implying that firms were not simply free riding on their past performance. Firms that were expecting lower costs or larger benefits were more likely to participate.

4.21 Yachnin (1998) looked at ways in which voluntary and non-regulatory approaches (VNRIs) could be used more extensively in Canada to foster increased international competitiveness. The case study approach stated that some VNRIs can be implemented faster than regulations. They may require less monitoring and reporting. However, several recent studies have questioned the effectiveness of VNRIs compared to that of regulations, with one report by Environment Canada concluding that sole reliance on voluntary compliance was ineffective in achieving even marginally acceptable results. There is a strong public preference for regulations and a lack of confidence in the corporate sector which deter government from moving towards VNRIs

4.22 The study concluded that there are important links between VNRIs and competitiveness, as participants in the market anticipate enhanced market shares due to improved cost-competitiveness in some cases, and to improved reputation in their markets. Although there is little solid proof, these relationships appear to drive participation. VNRIs with verifiable performance criteria and international recognition (ISO 14001 and some eco-labelling schemes) can help enhance market share. Those that allow the participants flexibility, such as codes of practice and negotiated agreements can boost trade competitiveness by cutting costs. Finally, new codes of practice can lead to new market opportunities in the form of eco-tourism, or new product lines.

[4] The 33/50 programme was launched by the EPA in 1991 to encourage firms to voluntarily reduce their emissions of 17 high priority toxic chemicals. The aim was to reduce the aggregate releases of these chemicals by 33% by 1992 and by 50% by 1995. Firms had complete flexibility in the amount of reductions undertaken and the means used to achieve the reductions. EPA asked firms to do this at source rather than at end-of pipe. The EPA reported that by the end of 1993, total releases declined by 46% relative to the 1988 baseline. However, 40% of this reduction was achieved before the program came about (Khanna and Damon 1998)

4.23 A recent European study (Rennings et al 2003) investigated the impact of the EU Environmental Management and Auditing Scheme (EMAS) on environmental innovations and competitiveness in Germany, by analysing data from twelve in-depth case studies and a survey of a sample of EMAS-validated facilities. The study found a positive impact of EMAS on environmental innovations among surveyed facilities; the scope of these innovations depended on the age of EMAS and the organisational scope of implementing the measure in a given facility. EMAS participants tended to compete on quality rather than price.

4.24 The study found a weak relationship between EMAS on indicators of market success, although positive impact on the increase of turnover and exports can be shown if a facility had achieved significant learning by EMAS. Hence the authors conclude that a better linkage between environmental management and innovation management could improve competitiveness.

4.25 A recent UK based study (Peters and Turner 2004) assessed the efficiency of voluntary initiatives and the role that they could play in assisting small and medium sized enterprises (SMEs) to encourage environmental performance improvement. The study, based upon local-scale industrial estate voluntary initiatives, showed that SMEs can benefit from such approaches, albeit with external guidance from local authorities and associated agencies and positive involvement from the industry. As voluntary initiatives are based on co-operation and consensus, initial efforts to engage businesses in participating are crucial.

Effect of regulatory form on technical innovation and diffusion

4.26 Compared to a substantial body of literature that presents theoretical frameworks of technological innovation and environmental policy, there is relatively sparse empirical analysis of the effects of alternative policy instruments on technological innovation in pollution abatement, primarily as Jaffe et al (2002) conclude, due to a lack of reliable and available data. There has been less research focus on the effects of alternative economic instruments on pollution abatement technologies and more on energy-efficient technologies because data availability has been less of an issue. Theoretical models in this area have produced mixed results, and the situation is not much different in empirical evidence.

4.27 Jaffe and Stavins (1995) were pioneers in investigating and comparing the competitive effects of varied regulatory instruments in empirical research. They studied the effect of taxes, technology adoption subsidies and technology standards on the diffusion of new technology. Market-based and command-and-control mechanisms were quantitatively compared by estimating the economic penalty that firms, through their actions, reveal to be associated with violation of standards.

4.28 The findings suggest that in determining conservation technology decisions;

- The prevailing level of efficiency was significant
- Energy prices had a positive effect
- Technology costs had a negative sign and are almost twice as important as energy costs

4.29 Further dynamic testing showed that the effects of energy prices and technology costs were significant in conservation energy decisions, but the effect of technology costs was nearly 3 times that of energy prices.

4.30 Jaffe et al (2002) reviewed the empirical evidence on the innovation effects of economic instruments and concluded that the empirical evidence generally tends to follow the theoretical findings that market based instruments are more likely to have a positive impact over time than command and control instruments on the innovation and diffusion of environment-related technologies. However, there are some inconsistencies too – the diffusion of energy-efficient technologies is more sensitive to variation in the cost of adoption than to changes in energy prices. These and other gaps in evidence ought to be addressed in research to enable a more robust picture of the effects of alterative policy instruments on technological innovation.

Concluding statements

4.31 Despite the many theoretical propositions in the literature that favour economic instruments as a means of regulation that is more effiicent, very few studies have managed to provide empirical evidence that robustly concludes that market-based mechanisms are more effective than traditional command-and control systems in bringing about positive competitiveness effects. This may be to do with the way in which they have been designed and implemented.

4.32 Hahn (1989), for example, examined the experience with regulations that were implemented in the form of marketable permits and charges and concluded that, in reality, they were rarely introduced in the way that economists would have conceived in textbooks. Hahn examined select schemes in the USA and Europe (emissions trading, lead trading, effluent charges) and found that virtually all systems relied on existing systems. He also observed that most of the charges to date had not generated cost savings, implying that polluters had not been induced to adopt a least cost approach in meeting environmental objectives as a result of implementing the charges. The experience with marketable permits was similar.

4.33 According to Hahn and Stavins (1992), earlier studies that had empirically tested the efficiency of marked based instruments had used stylised benchmarks for comparison – for example the ratio of the cost of a command and control programme to a least-cost benchmark, instead of using costs from actual trading programmes. Economists also assume no

transaction costs when moving to market-based systems, which in practice may not be the case.

4.34 A growing body of literature argues that political economy factors play a significant role in determining the relative efficiency of different forms of regulation. Buchanan and Tullock (1975) use a public choice framework using a positive theory of externality control policy that allows for the isolation of influences on policy formation. Decisions on alternative policy instruments are affected by the preferences of those subjected to them, i.e. industry influence. The theory suggests that firms will prefer direct regulation over taxes, as emissions standards may restrict new firm entry and raise the profits of existing firms in the market. On the other hand, taxes may reduce the market value of the firm.

4.35 Regulation design, stringency and efficiency can influence the relationship between environmental regulation and competitiveness. Stringency may well be less important than the design of regulation itself, as this review suggests. As Jaffe observed in a 1999 presentation, "we all agree that much existing regulation stifles innovation – replacing inflexible regulations with incentive based approaches would make regulation either less stifling or else positively innovation enhancing – why don't we focus on achieving this?"

5 Implications for the next steps

Research questions posed in the literature

5.1 This literature review has shown that environmental regulation can adversely affect national productivity levels and growth under some assumptions and conditions. But, it does not show that more stringent regulation necessarily is a significant adverse determinant of trade competitiveness or that it brings about general 'industrial flight' of capital or increased investment flows to 'pollution havens' (although there are some examples of this).

5.2 The review has demonstrated, and provides examples of, the possibilities for 'innovation offsets' and efficiency gains following from increased regulatory stringency – even amongst some of the most energy and pollution intensive sectors and firms. But, this conclusion itself is dependent on certain assumptions – most notably, on the pace of technological change and the degree to which firms can tap into it, on existing inefficiencies amongst the affected firms and on efficiency in the design and use of the regulatory interventions.

5.3 There are two issues on which there is relatively limited empirical evidence in the reviewed literature, namely the market conditions, on the one hand, and the form of regulation, on the other, that are most conducive to positive effects on competitiveness from more stringent regulation. These issues have been addressed in the literature in theoretical terms but the empirical evidence base remains under-developed.

5.4 This is reflected in the questions identified in some of the recent studies as being a priority for future research. Jaffe et al (2002), for example, suggest that the key questions for future research include the following:

- Detailed examinations of the kinds of policies and the nature of the private sector institutions that are most likely to generate innovative, low-cost solutions to environmental problems;

- Exploration of the broad linkage between technology and environment – specifically the effect of environmental policy interventions on the process of technological change – in order to address the anomalies that Jaffe et al observe in the empirical evidence about the theoretical presumption that market-based instruments are more efficient in this regard;

- Investigation of induced technological change and its consequences for environmental policy that go beyond studies that examine whether or not such effects exist to analyse, in a variety of sectors, the circumstances under which the effects are large or small.

5.5 The OECD study (2003) suggested research priorities that were more focused but were similarly concerned with the nature of the broad policy framework in which regulation is designed and implemented. The author's specific suggestions for research were as follows:

- The implications for business of sectorally targeted ecotax and other regulatory packages involving the recycling of revenue or the use of pollution abatement subsidies as a supplement to environmental regulation or taxes;
- The relative merits of using ecotax revenues to reduce factor taxes (e.g. payroll taxes) as compared with sales taxes;
- The appropriate criteria for defining sectors for the purposes either of selective exemption from ecotaxes or in order to devise revenue recycling regimes for particular sectors;
- The use of border tax adjustments to offset competitiveness effects;
- The significance of plant closures in achieving cost-effective pollution reduction.

5.6 The need for a wider policy framework for consideration of regulation options was acknowledged by the Carbon Trust (2004, 2005) in its identification of the potential significance of revenue recycling and/or 'announcement' policies on the competitiveness impact of the EU ETS. It is commissioning further work to explore these two effects and any other aspects that might have caused differences between the two macroeconomic models it used to estimate the aggregate national productivity effects of the Scheme.

5.7 The research areas identified in the literature above all acknowledge that regulation may have to be considered in a broader policy framework than one that simply seeks to rectify market failures by altering the costs and demand structures in which firms operate. Kemp (2000) calls this a "modulated" approach to regulation in which government policies involve "changing the rules of the game or changing the way that the game is played". The examples he provides of this approach are generic – "bringing in outsider firms with different interests and capabilities", "securing a (future) market for a new product". He also argues that, in addition to game management and changing the economic and legal framework conditions (e.g. through use of taxes and/or standards), there is also the need for policy to be oriented towards "capacity building – enhancing the ability of companies to design environmentally improved products and their ability to adopt clean technologies".

5.8 Kemp's arguments are not based on traditional economic theory nor are they supported by fresh empirical evidence. But, his case is based on a proposition that resonates with the findings of this literature review. This is that (increasingly stringent) environmental regulation – even of an efficient form - may not be sufficient to bring about induced

innovation and /or efficiency gain effects and that the conditions under which the latter are, or are not, secured are not well understood.

5.9 The explanation that Kemp advances for the possible inadequacy of market based mechanisms is that incumbent firms are often dominated by their corporate legacy of expectations, systems, capabilities and outlooks. These lock the businesses into trajectories that are difficult to shift even when the framework of costs and demand are altered significantly by regulatory standards, taxes and other means. He appeals to a body of literature on the determinants of technical change to justify this position (e.g. Nelson 1994). We would add the thought that the conditions he describes are very likely to characterise the most pollution intensive sectors which tend to be capital intensive with high entry barriers and a tendency for process secrecy (such as chemicals, electricity production, pulp and paper manufacture, cement and metal manufacture).

5.10 The thrust of Kemp's modulation approach gives a far more proactive role to government intervention than we suspect would be comfortable for most of the economists whose work we have referred to in this review. However, it seems to us that research would be warranted to consider the effectiveness and efficiency of the various "entrance points for modulation policies" that he and others (such as Rip and Schot (1999) and Geels (1999) have identified, as follows:

- Improved processes for anticipation and assessment of technological challenges, possibilities and options;
- Enhanced networks for learning and interactions through, for example, collaborative research;
- Provision of niches protected against market selection pressures to explore technological solutions to the environmental challenges, acting as a learning environment and possible stepping stones for overall system change.

Relevance to the UK

5.11 Our terms of reference required us to consider the extent to which the literature drew on and/or was specifically relevant to UK circumstances. As we have demonstrated in the preceding chapters, there is little evidence that is specific to the UK apart from the recent work of the Carbon Trust which explored the implications for the UK economy and specific sectors of the implementation of the European Emission Trading System.

5.12 We have broadened this particular aspect of our brief to consider whether the review findings hold particular implications for the UK and, if they do, what this might imply for the research priorities for UK government departments and agencies.

5.13 There are two aspects of the literature which could hold particular implications for the UK. The first is simply whether the concerns it addresses are of relevance to the UK's international competitiveness. The second is whether there are any implications for the formulation and conduct of UK environmental policies.

The relevance for UK competitiveness

5.14 It was not part of our brief to review the competitive position of the UK and to consider the likely effect of (increasingly stringent) environmental regulation on that position. Therefore, we can only explore this issue with a light touch within the confines of this research.

5.15 Figure 5.1 presents some core statistics for UK manufacturing and service sectors listed in descending order of value-added per person employed. For the purposes of this light touch exercise, data was more readily available for manufacturing than for the service sectors. The figure suggests that the UK has competitive advantage (as measured by labour productivity or trade comparative advantage) in a number of sectors that are large fuel users, have high environmental protection spend relative to their value added and are characterised by relatively large firms (in employment terms). The sectors are shaded in the figure and comprise electricity, gas & water, chemicals & man-made fibres, food, drink & tobacco and transport & communications.

Figure 5.1: Productivity, competitiveness and energy/environmental intensity

Sectors	Value-added per person employed (2005)	Comparative advantage index (2003)	Total fuel use (m tonnes oil equivalent) (2003)	Ratio of environmental protection spend (2003) to GVA (2005)	Employment in firms with 250+ employees as % of total employment (2003)
PRODUCTION					
Electricity, gas and water	88.1	1.53	63.6	19.6	15.1
Chemicals	75.1	1.57	7.6	36.9	5.7
Transport equipment	47.2	0.98	2.0	11.6	5.0
Food, drink and tobacco	46.1	0.73	5.3	19.4	5.0
Electrical and optical equipment	43.9	1.28	1.1	3.4	2.0
Pulp, paper, publishing and printing	41.5	0.38	3.1	15.0	1.1
Other non-metallic products	41.5	0.94	3.3	23.3	1.9
Machinery and equipment	40.4	1.26	1.2	26.4	2.0
Wood and wood products	34.0	0.19	1.7	8.3	0.5
Rubber and plastic products	33.2	0.96	2.5	17.4	2.3
Basic metals & metal products	31.9	0.72	10.4	21.5	0.7
Other manufacturing	28.5	0.57	2.1	15.7	0.7
Textiles, clothing and leather	27.0	0.45	1.4	23.8	1.4

Figure 5.1: Productivity, competitiveness and energy/environmental intensity					
Sectors	Value-added per person employed (2005)	Comparative advantage index (2003)	Total fuel use (m tonnes oil equivalent) (2003)	Ratio of environmental protection spend (2003) to GVA (2005)	Employment in firms with 250+ employees as % of total employment (2003)
SERVICES					
Transport and communication	42.3		32.0		
Financial services	38.6		1.3		
Business services	35.5		3.5		
Public admin and defence	27.4		4.1		
Construction	26.8		2.9		
Wholesale and retail	24.4		7.0		
Education	21.1		2.7		
Health and social work	20.0		3.5		
Hotels and restaurants	17.1		1.4		
Sources Value added per person employed, Cambridge Econometrics, Regional Economic Prospects, 2005 Comparative advantage index = (exports/imports)/(total manufacturing exports/total manufacturing imports); ONS Total fuel use, ONS Employment by firm size, SBS SME Statistics					

5.16 This observation is consistent with the findings of research by Cole et al (2004) on the determinants of pollution intensity across manufacturing sectors in the UK. They conclude that "the UK does not appear to enjoy a comparative advantage in labour-intensive industries and, if a degree of specialisation in the manufacturing sector is to be maintained, it is likely to be in those sectors that use at least moderate levels of physical and human capital". The authors point out that, from their analysis, these characteristics appear to contribute to pollution intensity and that, consequently, "offsetting reductions in emissions will be necessary elsewhere".

5.17 However, they could also have drawn another conclusion, namely that, for the UK, a critical issue could be how to maintain – and, indeed, further increase - its comparative advantage in these sectors at the same time as reducing their pollution intensity. In other words, any policy implications from this review on efficient forms of regulation could have particular significance for the UK given its pattern of comparative advantage. We suggest that further disaggregated research into this question would be helpful in identifying those specific sectors where it will be most desirable to ensure that regulation secures competitive as well as environmental outcomes.

The relevance for UK regulatory policy

5.18 The review of the literature demonstrates that efficiency gains and induced innovation effects can be derived from (more stringent) regulations so that competitiveness and productivity can be enhanced at the same time as achieving environmental objectives. But, it requires an efficient form of regulation to secure this outcome and, even then, the regulations may have to be incorporated in a package of complementary measures in order to bring about changed behaviour amongst the relevant businesses.

5.19 This conclusion is consistent with recent policy announcements and proposals in the UK. Thus, the UK government's sustainable development strategy published in 2005 ('Securing the Future') has a chapter devoted to the package of measures (including regulation as just one element) needed to enable, encourage and engage people and communities to adopt sustainable development practices. The package is directed at changing the behaviour of individuals but the principle is one that could be extended to businesses.

5.20 The Carbon Trust (2005) makes proposals that do just that. It identifies and assesses five options for packages of measures each of which covers the span of business and public sector sourced emissions but which, it suggests, reflects philosophically different approaches to policy. However, each package contains a mixture of economic instruments (providing price signals through taxes and trading) and bottom up policy instruments (which the Trust describes as measures-based instruments such as building regulations and Carbon Trust interventions).

5.21 The measures do not include additional policy support to accelerate the adoption of leading-edge efficiency technologies and the development of new energy efficient and low carbon technologies (which fell outside the scope of the Trust's study). However, it acknowledges that such support could form a component in an integrated package of policy instruments and one that offers enormous potential for energy saving. As the Trust points out, international data suggests that higher domestic energy prices do not in the long-run increase national energy expenditure – implying that mechanisms have been deployed, including innovation, in response to energy price increases that reduce energy costs per unit of output.

5.22 The conclusions of our literature review strongly suggest that the approach proposed by the Carbon Trust – and the options for packages of measures it identifies – should be taken very seriously by UK policy-makers.

Further research

5.23 As this review has shown, there has been a limited amount of evidence generated on the relationship between environmental regulation and competitiveness based on the experience in the UK. This situation has improved recently as data have become available on sectoral

pollution intensity and pollution control expenditure and as research has been carried out using the data.

5.24 Most notably, the Carbon Trust has contributed significantly to our understanding of the relationship between UK competitiveness and regulation packages of different forms. Indeed, we suggest that its research on this relationship (Carbon Trust, 2005), and its intentions to build on this work, are likely to address the need for general equilibrium and macro-econometric modelling of the national UK impacts of different packages of environmental regulation. The Trust has also made significant contributions in the development of 'bottom-up' technology models of sectors (using engineering-based abatement curves) and competitiveness models of particular sectors (e.g. electricity production).

5.25 There are three areas where we suggest further research would be helpful:

- Analysis of inter-sectoral patterns and trends in UK competitiveness to identify the influence of environmental regulation and where increased regulatory stringency could be potentially damaging to competitiveness if handled inefficiently (e.g. chemicals).

- Investigation of the effectiveness of different forms of environmental regulation and complementary measures in competitive non-energy intensive sectors with high fuel use and/or high environmental protection spend relative to their value added and populated by small and medium-sized firms (e.g. in mechanical engineering and business services).

- Assessment of the impact of regulation on innovation within specific sectors or firms that are pollution intensive where intensified regulation could challenge their marginal competitive advantage (e.g. food, drink & tobacco and glass, ceramics & cement). A retrospective and longitudinal study of these sectors would be particularly valuable to explore the effectiveness of their response to a variety of regulatory regimes – especially through technological innovation.

Case Studies

5.26 There have been some recent contributions to the literature that provide case studies of the way in which individual businesses and industries have responded or might be expected to respond to increasingly stringent environmental regulation in a UK context. They cover some of the sectors referred to above in the recommended areas for further research. We suggest that Defra might like to consider building on these case studies to demonstrate the ways in which such regulations affect competitiveness.

5.27 **Hitchens et al (2001)** investigates the impact of Best Available Technology (BAT) on the competitiveness of existing plants, focusing on three industries: cement, non-ferrous metals and pulp and paper. The authors used a case study approach comparing the economic

performance of plants that have adopted elements of BAT with those that did not do so. This process gives a clear indication into the potential effects of regulatory stringency on competitiveness across sectors.

5.28 **The Carbon Trust (2005)** analyse the potential for different policy options to contribute to reducing carbon emissions from business and public sector energy use, associated impacts on cost and competitiveness and the implications for possible packages for reform for the Climate Change Programme. This UK focused report is a rare step into the relationship between environmental regulation and competitiveness in non-energy intensive sectors, some of which may be as exposed to regulation as 'dirty' firms, and represent a much greater share of economic activity. The report covers four entity/use types:

- Large energy intensive sectors for which more than a third of their emissions are covered by EU ETS or the UK's Climate Change Agreements – examples are aluminium, paper, cement and lime, food and drink, chemicals, steel
- Large non-energy-intensive users covering both low energy-intensive manufacturing large service sector firms (>50 employees in former and >250 employees in service sector)
- Public sector, covering all government estates
- SMEs defined as firms with less than 50 employees in manufacturing and 250 employees in services

5.29 The report concludes that the ability of sectors to pass increased costs through to consumers is a crucial determinant of the potential competitive effect of regulation. Cost pass-through in the aluminium sector was identified as being particularly problematic, putting the sector at significant risk. Most other sectors were able to pass costs to consumers relatively easily in the medium term.

5.30 **Berkhout (2003)** reviews the literature and industry funded studies examining the potential impact of the EU REACH Directive on innovation, competitiveness and employment, and finds that the negative impacts have been largely overstated and that insufficient account has been taken of broader social and environmental benefits. The report also presents a qualitative assessment of the REACH proposals against a number of factors influencing innovation and the characteristics of the regulation that are likely to spur innovative activity in the sector.

5.31 The study identified three case studies as appropriate in terms of reflecting different types of supply chain and raising particular issues – manufacture of silicon wafers for use in semiconductors, manufacture of coated cans for food packaging and fragrances used in cosmetics and household products.

5.32 The broad findings from the case studies indicated that REACH is unlikely to have a negative impact on the competitiveness of firms in the silicon wafers and can coatings case studies. The regulation may have some impact on the profitability of firms in the manufacture of fragrances. Overall, the potential annual costs of REACH to the sectors studied were relatively low.

Annex A: Template for reviewing and summarising the literature

Title, Author etc
Origin of research/relevance to the UK
Broad purpose/summary of content
Definition of Competitiveness
Component (productivity/trade etc)
Level (nation/sector/firm)
Other
Nature of Regulation
What is being regulated?
Type of regulation (permits/target driven reduction levels)
Origin of regulation
Details of implementation method/flexibility of implementation?
Other
Methodology
Method for testing relationship between environmental regulation and competitiveness
Level of analysis (International, sectoral, firm)
Missing variables/information gaps

Estimates of the relationship
Assumptions underpinning findings
Other
Findings
General
Regulation – estimates of net impacts?
Competitiveness – estimates of net impacts?
Positive, negative or no relationship?
Other
General Comments/Implications of findings
Major Sources/Other Papers to Investigate

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Annex C: Review of methods and results

Introduction

1. Economic literature uses a range of methods to assess the relationship between environmental regulation and competitiveness. Those that estimate the impact on trade flows and net exports tend to adopt neo-classical assumptions and old and new trade theory models, whereas those that study the impact on economy wide productivity or growth use general equilibrium approaches.

2. At a sectoral level, more econometric approaches are applied, whereas at firm level, relationships are mainly investigated using a hybrid of analyses of existing statistical data e.g. combined with either a selection of case studies or a survey to gain more detailed data on subjects such as environmental management. Several of the more detailed analyses are based on case studies, including Porter's own (1995).

3. This annex provides an overarching analysis of the methodologies used in the literature to study the environment-competitiveness links. Differences between study methodologies could occur either due modelling approaches, study design and modelling mis-specifications. Besides providing a macro assessment, we also present an illustrative example where we compare two similar studies that had adapted different approaches and get mixed results.

Methods and quantitative results from the literature

4. The table below provides a summary of the quantitative estimates based on some of the key empirical studies we reviewed alongside other literature. As is obvious, there is no coherent distribution of evidence across the various hypotheses in the environmental regulation-competitiveness debate.

5. We found that even among the handful of studies that are empirically robust in testing the relationship between environmental regulation and competitiveness, there was significant divergence of evidence that led us to conclude that it is somewhat mixed and subject to several methodological constraints (Table C1).

Table C1: Exploring the relationship between environmental regulation and competitiveness: numerical estimates	
Joshi et al, *Estimating the Hidden Costs of Environmental Regulation*	
Method	Estimate
PACE Plant level data from 55 steel mills from 1979-1988 is used to estimate a translog restricted cost function (second order Taylor series), with visible pollution abatement operating expenditures as an index of quasi-fixed regulatory restriction. The translog function is a flexible functional form that does not impose prior restrictions on scale economies or substitution of inputs in response to changes in relative input prices, technology and regulation. A system of structural equations that incorporate costs drivers, including	A $1 increase in the visible costs of environmental regulation is associated with an increase in total cost (at the margin) of $10-11, of which, $9-10 are hidden in other accounts. The findings suggest that inappropriate identification and accumulation of the costs of environmental compliance are likely to distort costs in firms subject to environmental regulation.

Table C1: Exploring the relationship between environmental regulation and competitiveness: numerical estimates

production volume, input prices, technology, regulation and their interactions is constructed.	
Reinaud 2005, *Industrial Competitiveness under the EU ETS*	
Method	Estimate
The total cost of emissions trading in this study is the sum of the direct and indirect costs. The total costs are then calculated under two scenarios: companies must abate either 2 or 10% of their ex-ante emissions Effects on either profit or product prices are estimated, assuming that industry would seek to transfer this increase in cost be means of an average pricing strategy.	Carbon Price/tCO2 — BOF — EAF — Cement — News-print 5 — 4% — 0% — 9% — 1% 10 — 7% — 1% — 17% — 3% 15 — 11% — 1% — 26% — 4% 30 — 22% — 2% — 51% — 8% 50 — 37% — 3% — 86% — 14%
Patry and Lajeunesse, 2001, *Environmental Regulation and Productivity: New Findings on the Porter Hypothesis*	
Method	Estimate
An econometric model is constructed. Total factor productivity growth is measured by the Torqvist Index. Given that a host of factors influence TFP growth, an equation is required to relate TFP growth to an indicator of the importance of environmental regulation and to a series of control variables. Regulation stringency is proxied by the change in the ratio of the value of investment in pollution-control equipment to the total cost in a particular industry at a particular time. While a static component is included, 1, 2 and 3-year lags are added to accommodate the dynamic feature of the Porter hypothesis. Results are also calculated using moving averages.	The long-term contribution of the environment variable (representing stringency of regulation) is 0.001 (24% of average TFP growth) in sectors exposed to competition and 0.0008 for those sectors which are less exposed.
Petr Hanel, 2003-08, *Impact of Innovation Motivated by Environmental Concerns and Government Regulations on Firm Performance: A study of survey data*	
Method	Estimate
Bi-variate tests are carried out to test the null hypothesis, that there is no relationship between the objectives of innovation and their impact on the bottom line and other performance indicators. The major shortcoming of the bivariate tests is that the relationships involved may be influenced by other industry, firm and innovation characteristics that are not controlled for. Multivariate regressions are therefore used to estimate the probability that innovations motivated by environmental concerns and regulatory compliance improve a firm's performance. These tests included variables to proxy the effect of technological opportunity, industry life cycle, competitive conditions, firm size R&D, government support programs and region-specific effects.	• Among firms in the SCI survey (Statistics Canada Innovation Survey 1999 which provides data on innovating firms that launched new or improved products or processes in response to government regulation and/or environmental concerns), 74.7% reported 'reduction of environmental damage' and 71% response to regulation as reasons that led to innovation. • According to the bivariate tests, the highest incidence of innovating firms motivated by environment/compliance was in the medium technology sector (OECD classification) and the null hypothesis (that there is no relationship between the objectives of innovation and their impact on the bottom line and other performance indicators) can be rejected for low and medium technology firms. The result is less clear for high technology sectors. • According to multivariate regressions, firms that pursued the reduction of environmental damage as one of their innovation objectives were more likely than other innovators to report that innovations improved their performance. • *The effect of regulation on innovation on the firm's performance ranges from inconclusive to negative,*

Table C1: Exploring the relationship between environmental regulation and competitiveness: numerical estimates	
	depending on how the variable is defined
Brunnermeier and Cohen, 1999, *Determinants of environmental innovation in US manufacturing industries*	
Method	Estimate
A model of innovation is estimated using a panel dataset of 146 manufacturing industries tracked from 1983-92. The authors follow industrial organisation literature and add two variables to the equation to incorporate the effect of abatement pressures on innovation. The equation used looks at the number of successful environmental patents in a particular industry (proxy for environmental innovation) as determined by; • pollution abatement expenditures, the number of air and water pollution related inspections (proxies for abatement pressures), • export intensity (influence of trade on environmental research), • value of industry shipments (control for industry size), • industry concentration (four-firm concentration ratio used as an indication of market structure), • capital intensity and; • industry heterogeneity.	Ceteris paribus, increases in pollution abatement expenditures (abatement pressures) are associated with a small but significant rise in environmental innovation. The magnitude of the effect is small (0.04% increase in patents per $1 million pollution abatement expenditure), perhaps because the analysis excludes innovations developed in academia or in the non-manufacturing sectors
OECD report, 2003, *Environmental Policy in the Steel Industry: Using Economic Instruments*	
Method	Estimate
A partial equilibrium model of the steel industry is created to explore short to medium term impacts on the competitiveness of the industry of broader use of instruments to limit carbon dioxide emissions. The mode divides the world into three ten regions, and within each region steel may be produced in one of three ways. The authors assume a tax rate/quota price of $25 per tonne, which is relatively high.	An OECD-wide tax would reduce OECD steel production by 9% and world production by 2%. The tax would prompt some substitution from the use of pig iron to more intensive use of scrap in basic oxygen furnace (BOF) steelmaking. A consequent rise in scrap prices would weaken the competitiveness of scrap-based electric arc furnace (EAF) producers.
Newell, Jaffe and Stavins, The Quarterly Journal of Economics, 1999, *The Induced Innovation Hypothesis and Energy-Saving Technological Change*	
Method	Estimate
Using data from the Sears Catalogue, the authors compile a database of information on 735 room air conditioners (1958-1993), 275 central air conditioner models (1967-1988) and 415 gas water heater models (1962-1993). The authors describe the technological change in terms of product characteristics and use an econometric model to estimate the induced innovation hypothesis using characteristics transformation surfaces. The transformation surface shows the bundle of characteristics possible in a good given the	For both room air conditioners and gas water heaters, the estimates imply that energy efficiency improved by about 2% per year faster than it would have otherwise occurred without regulation, implying a cumulative effect of 7% for room air conditioners and 8% for water heaters.

Table C1: Exploring the relationship between environmental regulation and competitiveness: numerical estimates	
product cost and energy flow per unit of time. Technological change is investigated by approximating the parameters of the transformation surfaces, and simultaneously estimating how these parameters change over time.	
Gray and Shadbegian, 1993, *Environmental Regulation and Manufacturing Productivity at the Plant Level*	
Method	Estimate
The data used includes 122 pulp and paper mills, 107 oil refineries and 60 steel mills. Annual productivity and growth rates are calculated for each plant, using both labour and TF productivity. Averages of the productivity and productivity growth rates over the 1979-1985 period are then calculated. Relationships are analysed through regressions of plant productivity level and abatement expenditure, and average productivity growth rate and changes in abatement expenditure. The authors also relate the average productivity data to other measures of regulation – compliance status, pollution emissions, and enforcement activity. Limitations of some of the data mean that panel and cross-sectional analysis are used, but in some cases only one or the other is possible. Spearman correlations are also produced for the key variables related to both annual and average productivity. These are less sensitive to outliers than regular Pearson correlations and provide a robust view of the data.	Major results indicate that the effects of regulation and compliance costs are greater than first thought in several growth accounting studies. For example, this paper finds that a $1 increase in compliance costs appears to reduce total factor productivity by significantly more than the equivalent of $1, and perhaps as much as $4.
Helland and Matsuno, 2003, *Pollution Abatement as a Barrier to Entry*	
Method	Estimate
The authors investigate the impact of compliance costs on economic profit using changes in an industry level measure of environmental compliance costs produced by the US EPA. They estimate the impact of this on firm rents, represented by Tobin's *q* - the ratio of market value of the firms to its replacement costs. The premise behind this is that if firms earn no economic profit, then the equity value of the firm should equal its replacement costs. In the absence of economic rents, the value of *q* is 1. The second stage of the analysis estimates the impact of costs of compliance with regulations on the same firm rents value, *q*. This is achieved using a company-level fixed-effects model that covers 11 years and 1100 companies. Year controls are included to allow specific estimation of the intra-firm and intra-year impact of increases in the cost of compliance.	For the largest firm (top 25% of the distribution, an increase of 1 standard deviation in total capital expenditures on compliance results in a 4.5% increase in *q* - the ratio of market value of the firms to its replacement costs. For cost associated with water pollution control increased compliance costs produces an 11% increase in *q*. For air pollution cost increase, *q* increases by 8%
Parry 1998, *Pollution Regulation and the Efficiency Gains for Technological Innovation*	

Table C1: Exploring the relationship between environmental regulation and competitiveness: numerical estimates	
Method	Estimate
The authors derive the first-best efficiency gain from environmental R&D using a social planning model. The R&D efficiency gain is then derived in a competitive, decentralised version of the model under an emissions tax, tradable permits and a performance standard assuming the Pigouvian level of regulation is imposed. Simulations of the R&D efficiency gain under each policy, relative to that in the first-best case are then presented.	The induced welfare gain is greater under an emissions tax than tradable emissions permits, but the importance of this depends crucially on the size of the potential innovation – the R&D efficiency gain under permits is around 90% or more of that under an emissions tax for innovations that reduce abatement costs by up to 10%. It is around 60-70% of that under the emissions tax for innovations that reduce abatement costs by 40%
The Carbon Trust, 2004, *The European Emissions Trading Scheme: Implications for Industrial Competitiveness*	
Method	Estimate
The paper identifies three scenarios which correspond to the plausible ways in which the system may evolve over time. These differ in terms of price and allocation characteristics, as shown; *Scenario 1*: Price = EU 5/tCO2. Allocation as in UK National Allocation Plan (NAP), which promotes an 'electricity leads cutback' approach. This aims for the ETS to produce reduction of 5.5MtCO2 below the projections of emissions without it, and all this abatement is targeted at the power sector. Other sectors will be granted allocations equal to their projected emissions after implementing other elements of the UK Climate Change Programme. *Scenario 2*: Price = EU 10/tCO2. Allocations based on principles of NAP strengthened and extended to 2008-2012. This means that electricity still leads the cutback, sufficient to achieve national 20% reduction (electricity sectors allocation 28.3% below projected emissions level). Other sector allocations are again equal to their projected emissions. *Scenario 3*: Price = EU 25/tCO2. Allocation 30% below projected emissions targets for all participating sectors. A model is developed to evaluate the financial impact of the EU ETS given the market structures of the sectors involved. Full details are not given here, but its basis is in standard economic theory (Cournot Theory) of company behaviour in markets which are characterised by relatively high fixed costs relative to marginal operating costs. In these conditions, the theory is that companies have to maintain prices well above their short-run operating costs. If new companies enter the market, the price	• Electricity – A low proportion of its cost increase is required to be passed through to prices to maintain profits at the pre-EU ETS level. For scenario 1, a minimal price increase is required to cover the allocation shortfall. In scenarios 2 and 3, the sector would need to pass on 30% of the marginal cost increase to prices to maintain current profits. • Cement –Marginal production costs increase significantly as a result of the EU ETS (30%, 50% and 140% across the three scenarios). Despite this, only a marginal percentage (8% in scenarios 1 and 2) need be passed on to consumers as a result of the offsetting effect of the sector's allowance endowment. In scenario 3 this increases to 41%, and the price of cement would have to increase by 17.4% to maintain profits. • Paper – Again, this sector will likely be only marginally affected by the EU ETS. Proportions of marginal cost pass-through are similar to the cement sector (9% for scenarios 1 and 2, and 42% for scenario 3). • Steel – percentages of marginal costs that are passed to consumers are larger for this sector (33%, 31%, 63.3%). Aluminium – If smelters purchase electricity from the grid, the model suggests that increases in electricity prices could equate to 25%, 50% and 125% of current sector EBITDA operating profits. When modelled as a European market subject to imports, the model suggests that the 'loss-minimising' pass-through would see the sectors firms' profits fall by 15%, 30% and 20% across scenarios.

Table C1: Exploring the relationship between environmental regulation and competitiveness: numerical estimates	
will fall to a level where some companies can no longer cover fixed costs and drop out of the market. A rough equilibrium price is reached based on controlling the quantity of goods produced, or the production capacity of firms in the market – a state known as Connaught Equilibrium. Since the theory predicts pricing behaviour based on costs and industry structures, it can predict the extent to which operating cost increases (due to emissions trading) would be passed onto consumers.	

6. Although much of the general economic literature has tended to lean towards the effects of environmental regulation on international trade, there were relatively few empirical papers that we could identify as significant, both with regard to quantitatively estimating the relationship and being methodologically robust.

7. Jaffe et al (1995) suggested that the lack of apparent relationship between environmental regulation and trade flows could be due to poor data and lack of environmental accounting – In many studies, differences in environmental regulation were measured by environmental control or abatement costs as a percentage of value-added or other measures that depend critically on the accurate measurement of environmental spending, which may not be the case. Also, as the design of regulation shifts towards market based instruments, accurate accounting of pollution control would become more of an issue, as costs related to process as well as product or end-of pipe changes would need to be measured.

8. Only two of the studies that the authors reviewed accounted for differences in 'regulatory climate' between jurisdictions. If delays and litigation were the greatest obstacles to exporting or plant location, these will not be picked up by studies focusing on spending for pollution control equipment. Added to this is the difficulty of measuring the effectiveness of enforcement efforts.

9. Most importantly, the authors conclude that any study testing the regulation-competitiveness link must take account of both costs and benefits of regulation. In a majority of the studies that we reviewed as part of this study, firm response to regulation resulted in abatement costs being included in an estimation model. Measures of cost savings, diversification or reallocation of expenditure and other activities were hardly mentioned or used.

10. A recent study examining the evidence on environmental regulation and industry location (Levinson 2004) provided a critique by looking at the differing features of studies:

- Study Design limits the comparability of papers, since they are driven by different underlying assumptions and methodologies. Even studies using similar or identical methodologies can be incomparable as different samples, measures of stringency and independent variables might be chosen.

- Dependent Variables also differ between studies, but the authors find that the impact of this on the researcher's ability to detect industrial flight patterns is less significant than choice of methodology.

- Regulatory Stringency is proxied in a number of ways, and some, particularly environmental indices (which are very subjective) have obvious drawbacks. Studies using objective, quantitative data on pollution levels and costs are more convincing.

- Control Variables – Studies must control for factors such as better infrastructure, agglomeration economies and access to consumer markets, all of which are actors that will attract firms to regions with larger market size. However, the literature does not provide a consensus on the sign or magnitude of any of these control variables except market size. The authors view with suspicion models that fail to predict the signs of control variables.

- Geographical Units of Analysis – While differences in the unit of analysis are less crucial than those in the chosen methodology, there could be potential issues, including the fact that it might be easier for industries to relocate to other countries that are close by. This effect might however be cancelled out by the fact that regulatory stringency is likely to be at a more similar level in proximal nations.

- Level of Industry Aggregation – The selection of the industry sample may have some effect on results and comparability. Aggregations of firm-level data to higher level of aggregation are particularly problematic. There may be hidden characteristics of 'dirty' industries which make them less footloose than others, so by limiting a study to 'dirty' industries, there is a danger of bias in the results.

- Methodology, cross section versus panel data – The authors note that cross sectional studies tend to reject the pollution haven hypothesis, while panel date studies generally confirm it

- Endogeneity Correction – Studies that adjust the observed measure of stringency for industrial composition find more robust evidence of a moderate pollution haven effect.

Modelling specifications and their limitations

11. Studies conducted using data from the 1970s and 1980s investigating the impact of environmental regulation of productivity and growth often concluded that there was a productivity penalty at macro and sometimes at sectoral level (Barbera and McConnell 1988 and Jorgenson and Wilcoxen 1990) But several economists have subsequently attempted to explain why this may be the case. Studies based on the traditional measures of total factor productivity can be biased and result in measurement errors (Gray and Shadbegian 1993, 2002). Besides failing to account for changes in resources on environmental goods and assuming that firms are already in their production possibility frontier (DeCanio 1997) they also do not always take account of the 'output' from pollution abatement.

12. A recent paper by Telle and Larsson (2004) stated that methods that fail to account for improvements in environmental performance inevitably detect a negative relationship between environmental regulation and competitiveness. The authors in the study apply a method that accounts for emissions reductions by including them as inputs when calculating a productivity index, and conclude that when this variable is included, the sign of the relationship is positive, but not statistically significant from zero when it is excluded. In their

model, they do not assume the same production function structure for all firms in an industry, nor do they assume optimising behaviour. Hence improvement in abatement technology comprises one element of a firm's overall technical progress, and accounting for this factor can influence the sign of the relationship between regulatory stringency and productivity.

13. Measurement error in models can also lead to erroneous results. Gray and Shadbegian (1993) regressed productivity levels defined by the ratio of value-added to a weighted average of inputs, on the ratio of PACE expenditure to value added using plant level data. They found extremely adverse productivity effects in this study, but in subsequent work, the authors showed that their earlier results were extremely sensitive to econometric specification, and the large negative effects were due to measurement error in value added.

14. Matayas et al (2000) pick a previous study of environmental regulations and trade by Van Beers and Van den Bergh in 1997 which found that stricter regulations have some negative impact on bilateral trade flows between OECD countries. The aim of their paper was to show that these results were the outcome of a mis-specified model which does not consider country specific effects.

15. The authors conclude that for 'dirty' imports the results show that if country-specific effects are not accounted for, regulatory stringency in the importing country has a strongly significant negative effect on 'dirty' trade, while stringency in the exporting country seems to be positively related to it. This indicates that importing countries prefer to purchase from countries with high environmental standards. Van Beers and Van den Bergh however found no relationship between exporting country regulation and 'dirty' imports. Unobserved exporter heterogeneity and time effects tend to play an important role in 'dirty' trade than environmental regulations. In conclusion, the authors state that the relationship between regulatory stringency and trade cannot be investigated without considering the characteristics of importing and exporting countries.

16. Cole and Elliott (2003) test whether environmental regulations have any effect on the composition of trade and intra industry trade shares and factor endowments, using old and new trade theory models. The results suggest that if regulations are treated as exogenous, they are found to be negative and statistically significant determinants of intra-industry trade shares. If regulations are treated endogenously, the stringency variable increases in size and significance.

17. Several other studies present similar evidence for endogeneity correction (Ederington and Minier (2000)).

18. There is increasing debate among policy circles regarding the 'hidden costs' of environmental regulation, and the issues around their estimation and inclusion in models testing the regulation-competitiveness link. Joshi et al (2001) examine the extent to which accounting systems separately identify all the costs of environmental regulation. The authors estimate the relation between the 'visible' cost of regulatory compliance (costs that firms' accounting systems correctly classify as 'environmental' such as installation and maintenance of pollution control equipment and end of pipe emission treatment costs) and 'hidden' environmental costs embedded in other accounts (such as the indirect affects of environmental compliance that requires firms to substitute less polluting inputs for more polluting inputs or to change the production process to limit emissions). The results indicate that visible costs. as reported by

the firms' accounting systems, identify only a minor portion of the overall costs associated with regulatory compliance.

19. Overall, the results from the regression analyses were found to be highly significant and regulation was found to be associated with higher total costs than those accounted for by the various firms. A $1 increase in the visible costs of environmental regulation is associated with an increase in total cost (at the margin) of $10-11, of which, $9-10 are hidden in other accounts. The findings suggest that inappropriate identification and accumulation of the costs of environmental compliance are likely to distort costs in firms subject to environmental regulation.

20. It should be noted that the estimates hidden costs were based on a statistical association between the variation in total costs and variations in the reported visible environmental costs, which does not establish causality. And, environmental costs may lead to hidden benefits, such as improved quality, increased consumer appeal and lower contingent liabilities, which the estimations do not capture.

Study design and its limitations

21. A good example of results affected by study design is a study by Henderson and Millimet (2001) that conducts a nonparametric assessment of the impact of US state level pollution abatement costs on the spatial distribution of foreign direct investment (FDI) flows. It builds on a previous study that used parametric panel data models and found moderate evidence that capital flows are sensitive to abatement costs. The authors re-run the study using non-parametric techniques and find that their adapted techniques find a much less robust adverse impact of higher abatement costs on FDI flows. The impact of greater abatement costs is far from uniform across states, and where negative effects were still apparent, the effects were of considerably smaller magnitude than previously documented. This study is a classic example of the methodological constraints that could significantly affect the outcomes of studies.

22. An example of how study design makes a difference is that of a study by Hanel (2003) who attempts to test the relationship between proxies of stringency in regulation and innovation by using both bivariate and multivariate tests. The major shortcoming of the bivariate tests is that the relationships involved may be influenced by other industry, firm and innovation characteristics that are not controlled for. Multivariate regressions were therefore used to estimate the probability that innovations motivated by environmental concerns and regulatory compliance improve a firm's performance. These tests included variables to proxy the effect of technological opportunity, industry life cycle, competitive conditions, firm size R&D, government support programs and region-specific effects.

Modelling approaches and their differences

23. A recent report on the UK Climate Change Programme (Carbon Trust 2005) analysed the potential for various economic instruments in contributing to reducing carbon emissions from business and public sector energy use, associated impacts on costs and competitiveness and implications for reform packages for the Climate Change Programme.

24. They utilised four different models for conducting their quantitative analysis:

- 'Bottom-up' technology models of the industry public and building sectors that simulate the take up of different technologies over time using engineering based abatement curves, operated by Ecofys

- Competitiveness model of particular sectors with a separate model for UK electricity sector operated by Oxera

- Macro-econometric model of the UK economy, based on econometric interpretation of past data on UK energy and economy trends operated by CE

- General equilibrium model of the UK economy, based on classical economic production function theories, operated by OEF

25. While these models are appropriate in addressing different types of issues at differing levels of analysis (aggregate macro to micro), it is interesting to note the differences in results. For example, when estimating the impact of energy price changes in terms of elasticities of response at an economy wide level, the OEF model has higher elasticities in almost all sectors than the CE model, most notably in services. The data from CE suggest that in services, initial savings were due to the 'announcement' effect and that further price increases may not have much of an impact on their carbon emissions. On the other hand, the OEF model predicts much greater price sensitivity.

26. In terms of economic impacts, the results from the two models vary. Both use GVA as a measure to indicate gross impacts of the different sectors of the different packages but predict different impacts of higher prices and structural changes in the packages. In the OEF model, reduction in CO2 results in reduced economic production whereas in the CE model this is not the case. This trade-off according to the OEF model is much greater in energy-intensive sectors than in the non-energy intensive sectors. By 2020, these sectors lose about three times as much GVA as their non-energy intensive counterparts. In contrast, the CE model shows that the current scenario has negligible impact on GVA, while other packages increase GVA significantly.

27. Initial investigation regarding these differences suggests several things. There could be potential differences in the way revenues raised by economic instruments are measured and included in the modelling specification. A second factor could be whether and how awareness and investment effects associated with Climate Change Agreements are included in the models. Besides these two factors, there may be other differences in core assumptions. For instance, GEM assumes that economies fully utilise resources in cost-minimising ways. Econometric models do not include such an assumption but try to model the dynamic impact of various changes.

Differences in modelling approaches: an illustrative example

28. As an illustration of differences in modelling approaches, we compared two studies that explored the potential impacts of EU ETS on industrial competitiveness – Carbon Trust (2004) and Reinaud (2005). The main features of the two models are shown in Table C2 below.

29. Both studies assume that all firms share the average characteristics of the sector. However, the characteristics of the average sector differ between the two papers, since the Carbon

Trust focuses on the UK while Reinaud looks at average conditions across the EU-15. Both highlight the possible role for cost-reducing innovation in compliance, but it is unclear whether a proxy for this is included or modelling in either of the studies.

Table C2: Differences in modelling approaches: an illustrative example

The Carbon Trust (2004)	**Reinaud (2005)**
Focus Area : UK	Focus Area : EU-15
The Cournot Model Models sector characteristics based on costs and industry structures. • Market structure determined by the ratio of fixed and operating costs, demand elasticities, and degree of foreign competition • Limited number of firms, seeking to maximise operating profits to cover fixed costs and to generate surplus • Simplified model assumes all firms 'typical' of the sector average, and market is homogenous • Model represents 'geographical market' in question – UK for electricity and cement, Europe for paper and aluminium • Degree of price pass-through is determined by firm profit maximising behaviour, not as an a-priori assumption • Model allows firm entry and exit (though in cases we study this only happens for Aluminium) • Results are reported for the aggregate sector not individual firms	This paper uses a simple construction of compliance costs as below; For every source covered by an emissions trading, the cost of complying with the set goal can be described as follows: **Compliance cost = internal abatement cost + allowance cost (or - allowance revenue)** where the allowance cost is the expenditures incurred to buy allowances to cover emissions – the allowance revenue being the monetary value of allowances sold to other participants. Since it is not possible to predict to which degree plants or companies will undertake abatement investments to meet their objective and to which degree they will rely on the market to comply, we assume that every avoided emission carries a cost equal to the allowance market price. This leads to overestimating near-term compliance costs: 1) In theory, sources invest in internal reductions that are *less expensive than* the market price; 2) Some sources, in so doing, become net sellers and therefore offset part of their investment.
3 different scenarios <u>Scenario 1 Price €5/tCO2</u> Allocation as UK draft NAP: • Electricity on trend to projection minus 5.5MtCO2 by 2010 • Other sector allocations equal to projection/ updated Climate Change Agreement (CCA+) targets <u>Scenario 2/ Phase 2 Price €10/tCO2</u> Allocation based upon principles of NAP strengthened and extended to 2008-12: • Electricity leads cutback, sufficient to achieve national 20% reduction (=> electricity allocation 28.3% below projection) • Other sector allocations equal projection / CCA+ targets <u>Scenario 3 long term Price €25/tCO2</u> Allocation 30% below projected emissions / CCA+ targets for all participating sectors	Two different allocation scenarios: Industry would be allocated allowances covering either 98 or 90 percent of its CO2 emission needs (hereafter referred to as **10 per cent and 2 per cent scenarios**).The total cost of emissions trading in this study includes both this direct cost and indirect costs triggered by increased power prices.

Table C2: Differences in modelling approaches: an illustrative example	
The Carbon Trust (2004)	**Reinaud (2005)**
Based on UK National Allocation Plan	Not based on National Allocation Plans
Consider relative rates of cost pass through for all sectors, and determine competitive effect with regard to this as well as nominal marginal cost increases.	Looks at marginal cost increases, demand reductions, and price increases. Although one of the conclusions of the paper is that the ability to pass costs on to producers is crucial, the effect of this ability of the magnitude of effect of marginal cost increases is not detailed.
	Assume that all the allowances needed by industry and power generation in Europe will be supplied via the Clean Development Mechanism and Joint Implementation projects
	Industrial competitiveness depends on a number of factors including primary factor and other input costs, the availability of a skilled labour force, company's ability to compete on quality as well as cost and to generate product innovations. Some of these strategic considerations are outside the scope of this discussion. In particular, the possibility that the carbon constraint would trigger innovations leading to overall cost reductions, product improvements or other sources of competitive advantage is excluded.
	Assume that electricity pricing would lead to a full pass-through of the carbon opportunity cost in power prices. Uses average carbon content of electricity for EU, but in practice this varies by country.

30. It appears that although the two studies use different modelling approaches, the modelling assumptions regarding sectoral conditions partly determine the convergence or divergence of results, as shown in Table 4.3.

31. Cement: The Carbon Trust study states that import penetration is low in the UK (5%) and local producers therefore have some freedom to increase prices. The offsetting allowance to the sector in the UK as a result of its 'electricity leads cutback' approach' means that, although marginal cost increase are high, only a small amount of this will have to be passed through to consumers, and the effect on competitiveness will not be of the order suggested by the costs given in Table 4.2. Reinaud does not explicitly consider cost-pass through, and looks only at the competitiveness effect of increase in marginal costs. The Carbon Trust paper looks both specifically at the UK sector and allowances, and at the implications of cost pass-through, explaining the divergent results.

32. Steel: The Carbon Trust consider steel as a sector more open to EU competition, and where UK producers will be less able to increase prices due to intra-EU competition. The steel sector considered in the Carbon Trust study is therefore much more similar to that evaluated by Reinaud, and the marginal cost increase that both studies find are indeed of a similar magnitude. Small differences could be explained in part by the fact that different types of steel manufacture are assessed.

33. Aluminium: Both studies assume that electricity accounts for 35% of costs in this industry and that the cost of producing a tonne of aluminium in terms of electricity is 15000 kWh. As with steel, the Carbon Trust study models the aluminium sector based on a high level of exposure to the EU and wider global market. The results for the impact of the EU ETS on marginal costs are again similar.

34. The results from the two studies are given in Table C3.

Table C3 : Increases in marginal production costs as a result of the EU ETS

Sector	Paper	Allowance price/tCO2			
		5	10	25	30
Cement	Carbon Trust 2004 (EBITDA – increase in total costs after allocation)	27.3%	54.5%	136.3%	n/r
	Reinaud 2005	9%	17%	n/r	51%
Steel	Carbon Trust 2004	3.2% (cold rolled)	6.3%	15.9%	n/r
	Reinaud 2005	4% (BOF) 0% (EAF)	7% (BOF) 1% (EAF)	n/r	22% 2%
Aluminium (comparable results – Reinaud only produces this result at the 10 EU/tCO2)	Carbon Trust		5.2%		
	Reinaud (direct plus indirect impact, which include direct cost of industry compliance and indirect cost in terms of increased energy prices)		3.75%		

Concluding observations

35. The evidence of the relationship between environmental regulation and competitiveness is often fraught with methodological constraints. This is most apparent in economy-wide or international studies adapting macroeconomic modelling techniques that often incorporate neoclassical assumptions. Also, it is hard to control and adjust for all macro economic factors, including exchange rates and country-specific regulatory climate. A majority of studies exploring the link between environmental regulation and international trade flows are couched in conventional trade theory that has its own limitations.

36. At a sectoral level, the relationship is also affected by mis-specification of models and missing variables. In econometric approaches, when stringency of regulation is endogenous in a model, and is controlled for industry characteristics, resulting estimates of the relationship are more robust.

37. At firm level, results from estimation models can also be extremely sensitive to econometric specification. Cost information may not be comprehensively accounted for, especially those that are unobserved during data collation.

38. Most studies use abatement costs as proxies for stringency in regulation. This may have its own disadvantages. Quantifying firm behaviour or response to regulation in other ways such as in the form of cost savings, allocation of operating expenditure, or other forms of benefits such as the effectiveness of enforcement efforts are largely ignored.

39. Some of the underlying modelling assumptions may be quite simplistic - the Porter hypothesis assumes an efficient implementation and design of regulation resulting in firms reacting positively and engaging in innovative activity. This is a significant assumption, and as was reiterated during our review, largely unfounded or lacking in evidence. Many studies argue

against these and other assumptions underlying trade theory models of comparative advantage at national level.

40. DeCanio (1997) asserted that there could be a false trade-off between environmental protection and economic growth, mainly due to the assumptions that 'top-down' macroeconomic and general equilibrium models make when studying the relationship. Top down models often conclude a negative relationship, incorporating assumptions that firms maximise their profits, subject to technological constraints, and are already on their production possibility frontier. They also give much higher cost estimates than bottom up models based on econometric and engineering data.

41. These assumptions can be suspect on both theoretical and empirical ground, and the author suggests that firm characteristics and other organisational factors ought to be considered when estimating the relationship. While it may be the case that resources used on environmental goods can be used elsewhere, technical progress can lead to an increase in both environmental goods as well as ordinary goods. If cost estimates of an environmental policy are purely based on the change in the output of ordinary goods, without taking into account changes in the output of environmental goods.

42. Lastly, economic literature in this study area leans heavily towards the study of resource, capital and energy intensive sectors/industries and firms that operate within them. While the rationale for doing so is understandable from the policy perspective, since regulation is likely to disproportionately affect sectors with these characteristics, it also indicates a significant gap in data on other sectors such as agriculture, services and some natural resources sectors where impact could be significant with increasing energy use.

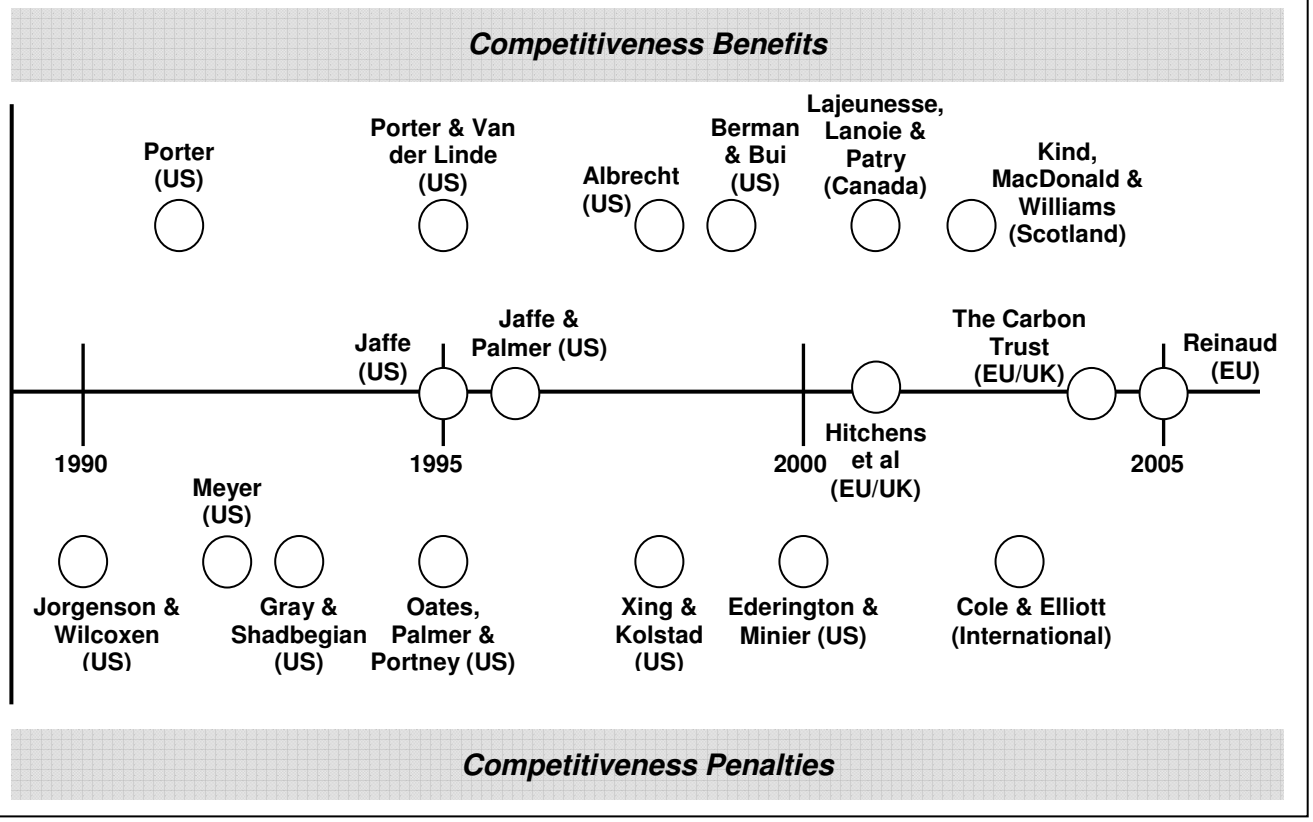
Annex D: Evolution of the environment-competitiveness debate

Introduction

1. The development of environmental regulation and changes in the understanding of the term 'competitiveness' are two obvious factors among the many that have driven the evolution of literature on the relationship between environmental regulations and international competitiveness. The dynamics of the political debate on the quality of regulation on the two sides of the Atlantic has also made an impact on the evolution of the scholarly debate, often via the activity of think tanks and policy institutes. This Annex is an overview of the progression of ideas on this subject. It is by no means a comprehensive account, but it has the purpose of providing the background to our review.

2. Some examples of important papers in the debate are depicted in Figure E1. It is immediately obvious that most of the studies are of US origin, with European literature beginning to appear very recently. The following discussion will cite some possible reasons for this trend and outline the broad evolution of ideas in the environment-competitiveness debate.

Figure D1: Some important articles in the evolution of the environment-competitiveness debate



The United States and Canada

3. The debate began in the US in 1970, when after increasing public concern over environmental issues, the US Environmental Protection Agency was formed and the Clean Air Act launched. Delegation of power to the EPA spawned debate in Congress and in academia on issues such as whether independent agencies regulate in the public interest or are captured by pressure groups, and the complex relationship between the political power of the executive and the independence of the regulators. The huge volume of environmental regulations that followed prompted concern over the purpose and effect of regulations. A structured, scientific debate on the economic impact of environmental protection emerged, and arguments were developed throughout the following decades and particularly in the early 1990s by several authors including Krugman, Oates, Palmer and Portney, Porter and Jaffe. Neoclassical economists of the early 1990s including Oates et al and Gray found that environmental regulations impacted heavily on production costs and competitiveness, but Porter's articles of 1991 and 1995 established a new approach whereby he claimed it possible to achieve environmental protection and maintain or improve competitiveness simultaneously. With two opposing camps established, Jaffe et al (1995) entered the debate to occupy the middle ground, finding in his 1995 article that "the truth regarding the relationship between environmental protection and international competitiveness lies in between the two extremes (neoclassical and Porter) of the current debate".

4. Since the early origins of the debate, further discussion of the conflicting theories and their implicit assumptions has ensued. Review and research papers including Albrecht (1998) 'Environmental Regulation, Comparative Advantage and the Porter Hypothesis' have attempted to contribute to, clarify and resolve the contradictory theories. The concept of competitiveness, and the task of defining it have been the weakness of many studies, and criticisms by Krugman (1994) and Wagner (2003) suggest that competitiveness does not exist as a concept at the international level, rendering some macro-level studies unable to usefully inform the debate. DeCanio (1997) also supports a move away from neoclassical general equilibrium models and towards analysis at the industry and firm level. The number of studies at the micro level has increased over time, showing evolution in terms of spatial focus as well as theoretical background.

Europe and the UK

5. The prevalence and clear evolution of US literature on the environment-competitiveness debate has not been matched in the EU or UK, where there is an apparent paucity of literature and much less structured argumentation process. Hall and Soskice (2001) provide a useful background on the institutional foundations of competitiveness. These foundations still vary to a large degree in Europe. Consequently, the EU's Member States provide different responses to the challenges posed by international competitiveness. The result is that it is very difficult to devise a single coherent approach at the EU level on this issue.

6. The more complex nature of the concept of competitiveness in the EU may in part explain the lack of authors able and willing to model the issue. As a group of distinct areas, the EU has different features and priorities when compared to the US. The need to preserve and balance efficiency and social fairness between independent states is one major difference, and the variety in institutions of economic governance across the EU another. Firms derive

competitive advantage from the "institutions in their home country that support specific types of inter- and intra-firm relationships. Any firms will be reluctant to give these up simply to reduce costs." Comparative institutional advantages, which are not seen to the same extent in the US, exist to complicate the concept of competitiveness in the EU.

7. Alongside the complexity of the competitiveness concept in the EU is the fact that environmental regulations, at least at the EU level, are a much newer phenomenon than in the US. While the US EPA began regulating pollution in 1970s, in Europe the Stockholm Conference of 1972 dismissed the environment as inferior in importance to the economic and social concerns in Europe. The Single European Act (1986) introduced environmental policy in the catalogue of Community policies. Research by AEA/Metroeconomica (2004) states that in terms of air pollution "the US standards have been in place for many years – many of the EC limits have emerged in recent years with the Air Quality Framework Directive (1996) and the four Daughter Directives". The conclusions of the Lisbon European Council of 2000, which claimed that Europe would be the most competitive region by 2010, and the Goteborg European Council on Sustainable Development (2001) have led to an increasing focus on competitiveness, and a recent increase in literature in European countries and on the EU as a whole. The launch of the EU Emissions Trading Scheme has provided further focus on the environment-competitiveness debate, prompting authors including The Carbon Trust (2004) and Reinaud (2005) to undertake sector-level studies into the impact of the scheme.

8. UK environmental policy before the Maastricht Treaty in 1992 was often informal, reactive, and formed from negotiations between industry and Government (POSTNOTE 'Environmental Policy and Innovation', Parliament Office of Science and Technology Number 212 Jan 2004). Control of air, water and land pollution was not harmonised until the Environmental Protection Act 1990. The concept of Integrated Pollution Control, as it was known in the 1990s, has developed with EU policy to become Integrated Pollution Prevention and Control, with the addition highlighting the shift away from command and control measures and towards pollution prevention. The shift is further accentuated in the UK by its Climate Change Programme, which was published in 2000 and reviewed in 2004. It includes a variety of market-based measures seeking incentivise businesses to find cost-effective ways to reduce emissions, including the Climate Change Levy, Climate Change Allowances and Energy Trading Schemes. The increased focus on the environment has contributed to an increase in volume of regulations in the UK, and recent literature covering the UK reflects this (Hitchens 2001, AEA/Cambridge Econometrics 2003, Carbon Trust 2004)

Current Concerns

9. After over a decade of debate, the literature on the impact of environmental regulation and competitiveness has understandably shifted in terms of focus and method. Globalisation has had a key role in steering discussion of the impact of environmental regulations on competitiveness away from macro level studies (Jorgenson et al 1990) towards consideration of international competitiveness at the firm and industry level. This shift has necessarily been mirrored by changes in analytical methods. From early general equilibrium models dealing with the debate at a macro level (Jorgenson et al 1990, Meyer 1992), increased use of econometric and trade models has become appropriate to perform sectoral, and in some cases, where data quality allows, firm-level analysis. Given the concerns articulated by Krugman and Wagner about the concept of competitiveness at a macro level, this shift has

been integral in improving and maintaining the robustness of research and the wider debate. Data quality is, as we have found, one factor that still troubles some studies attempting to look at the relationship at the micro level.

10. Evolution has also occurred in terms of regulations and their role in modelling studies. While some early papers lack detail on the regulations or regulation proxies used in modelling, development of environmental policy has led some authors to incorporate regulation in modelling by way of a proxy for regulatory stringency (Harris, Konya & Matayas 2000, Cole & Elliott 2003). A further influence on more recent literature has been the development of regulatory form which has seen the latest regulations progressing from command and control techniques towards market based instruments and voluntary measures. This has prompted discussions of regulatory impact to concentrate increasingly on specific types of regulation and on the influence of regulatory form (Johnstone 1998, OECD 2003, Carbon Trust 2004, Speck 2005).

Annex E: Literature Search Methods

1. The aim of this annex is to summarise the process of literature search that we had adopted in order to identify relevant articles and papers for the purposes of this study. It includes electronic databases and indexes to scholarly literature across economics and social sciences.

2. Specifically the following sources were used:

   - ISI Web of Science consists of the Science Citation Index, Social Sciences Citation Index, and Arts & Humanities Citation Index. They provide bibliographic details of articles from thousands of academic journals from 1981 onwards. Abstracts are available for many articles. This source was used to derive and identify a list of articles that were relevant for the study, using key search terms.
   - JSTOR is a digital archive collection of core scholarly journals, with multi-disciplinary collections within Arts and Sciences. This database was used to download and access the articles identified via the citation index as well as other articles.
   - Other sources such as Elsevier and Sciencedirect that publish and host an archive collection of scholarly journals, reports and books
   - Institutional websites - OECD, EU, World Economic Forum, Department for Trade and Industry
   - Websites of research institutions – Resources for the Future, AEI Brookings Joint Center for Regulatory Studies, IEEP, Avanzi and ZEW Centre for European Economic Research
   - Iterative search – Based on the bibliography of some of the most cited articles, individual electronic search was carried out in specific journals (e.g Journal of Management Science, Journal of Environmental Economics and Management, Journal of Environmental and Resource Economics)

3. We started the process of literature search by accessing institutional websites for reports and documents on competitiveness, such as the Global Competitiveness Report from the World Economic Forum website, the UK competitiveness indicators and other related reports from the DTI website, the EC competitiveness report from the EC Enterprise and Industry website, and relevant OECD papers from the OECD website.

4. For academic and empirical literature, where possible, all searches were limited to peer-reviewed journal articles in English, and working papers and discussion papers published by prominent research institutions relevant for the purposes of this study and included.

Academic literature published in peer-reviewed journals

5. We started the process of searching for literature in academic journals by accessing the ISI Web of Knowledge Social Sciences segment of the citation index to search for related articles using specific key words, some of which are mentioned below:

   - Environment *competitiveness

- Environmental regulation *competitiveness
- Regulation*trade
- Environment/Environmental policy*competitiveness
- Environment/environmental policy*innovation
- Environment/Environmental policy*productivity
- Environment/Environmental policy*trade
- Environment/Environmental policy*economic growth
- Industrial competitiveness
- Firm competitiveness

6. Our selection of key terms was guided by the Terms of Reference and the factors that we had identified for consideration in our analytical framework. In displaying the result the 'most recent first' criteria was applied.

7. We then extracted abstracts of the search results and reviewed each of the abstracts to identify the most relevant articles for the purposes of the study. The selection of the result was on the basis of subjective judgment of appropriateness and relevance considering the study research scope and the title of academic journal shown in the search result.

8. This meant that we restricted our search to research conducted in, and relevant to the USA, EU countries, Australia, New Zealand, Canada and the UK. We selected those papers that did not go earlier than the late 1980s, as the evolution of the regulation-competitiveness debate indicates that the literature in the area picked up momentum in the late 1980s and 1990s.

9. We also made sure that the content and coverage in the articles included the factors identified for consideration in the analytical framework when selecting relevant articles.

10. We also found many studies that discussed and linked 'environmental strategies', 'environmental management, standards or practices', 'environmental quality and 'environmental performance' to competitiveness indicators. We selected a few (Klassen 1996, Rennings et al 2003, Dowell et al 2000) to illustrate related arguments but were aware that a parallel study is looking into the relationship between environmental performance and competitiveness and decided not to explore this literature any further.

11. We accessed JSTOR, Elsevier and Sciencedirect in order to download our select list of journal articles derived from the citation index. We also did a separate search in JSTOR using similar key search words, to identify the most cited journal articles in the area that would be relevant for our study.

12. We conducted an iterative search using the bibliography of some of the most cited articles (for example Porter and van der Linde 1995, Jaffe 1995, Gray and Shadbeigan 1993) to source other relevant and useful articles.

13. At the end of this process, we were able to identify and review around 50 (check exact number) peer-reviewed journal articles.

Other relevant literature

14. We boosted our literature database further by accessing key institutional websites in order to identify discussion and working papers relevant to this research. This included a search in the OECD Environment website, the Europa Environment website and the Environmental Protection Agency (EPA) website. We applied similar search terms and criteria as discussed above to identify and select relevant papers.

15. The OECD website (http:///www.oecd.org) provides the option for searching by topic, and we searched within 'Economics', 'Energy, 'Trade', 'Environment' and 'Regulatory Reform' to begin with, using some of our key search words, and also did a whole website search to ensure we have covered other topic areas as well.

16. The EU Environment website (http://www.eu.int/comm/environment/pubs_en.htm) search function was used to identify relevant articles, studies and reports.

17. Additionally, we searched the publications databases of Resources for the Future (http://www.rff.org), the AEI-Brookings Joint Center for Regulatory Studies (http://www.aei.brookings.org/), the Institute for European Environmental Policy (http://www.ieep.org.uk/), Avanzi research consultancy (http://www.avanzi.org/eng/4_e.htm) and ZEW Economic Research Institute based in Germany (http://www.zew.de/en/). Again, similar search terms were used and criteria applied to identify papers within these sites in order to add to the existing database of empirical and academic literature for review. Most of the relevant articles that we found on the RFF database were discussion papers.

18. For the UK, we searched the publications database of the Carbon Trust (http://www.thecarbontrust.co.uk/carbontrust/about/about5_3.html), the Environment Agency (http://www.environment-agency.gov.uk/) but we focused our search to empirical and evidence based literature.

Annex F: Case Studies

1. Our review has identified three case studies from the literature which have particular relevance to the UK and to the recommended points of focus for further research outlined in Chapter 5. This Annex provides further details of the methodologies used and results obtained in the three case studies.

Hitchens et al (2001) The Impact of Best Available Techniques (BAT) on the Competitiveness of European Industry

2. The Integrated Pollution Prevention and Control (IPPC) Directive EC lays down a framework asking member states to issue operating permits that contain conditions based on BAT. The report investigates the impact of BAT on the competitiveness of existing plants, focusing on three industries: cement, non-ferrous metals and pulp and paper. The authors used a case study approach comparing the economic performance of plants that have adopted elements of BAT with those that did not do so. The application of methodology for each industry differed slightly. For example, the case study on the cement industry compared the average performance of plants in different countries having different degrees of environmental stringency, and hence different mixes of BAT and emission standards whereas the case studies for non-ferrous metals and pulp and paper involved the comparison of the economic and environmental performance of individual plants with and without BAT, irrespective of the EU country of origin. For the cement study, a BAT plant is identified as a plant with low emissions. In pulp and paper, BAT is identified as the number of BAT implemented by mills and the resultant emissions. According to the authors, the method adapted for cement was less preferred than those adapted for the other two.

3. The study uses many indicators of competitiveness – output measures such as profitability, productivity and growth and input measures such as physical and human capital, R&D spending etc.

4. The study finds that primary, front-end measures have a generally positive impact on productivity and plant performance, while secondary (end-of-pipe) measures have a mixed impact. When BAT measures as a whole are related to plant performance, strong BAT/environmental performers are not found to be at a disadvantage.

The Carbon Trust (2005) The UK Climate Change Programme: Potential Evolution for business and the public sector

5. The Carbon Trust study analyses the potential for different policy options to contribute to reducing carbon emissions from business and public sector energy use, associated impacts on cost and competitiveness and the implications for possible packages for reform for the Climate Change Programme.

6. It uses four separate models for to examine differential impact on a) the cost and scale of carbon delivery, sector by sector using bottom up abatement curves developed by Enviros, b) competitiveness impacts using microeconomic analysis of selected sectors developed by

Oxera and c) carbon and macroeconomic impacts using macroeconomic models by OEF and CE. It identifies four entity/use types:

- Large energy intensive sectors for which more than a third of their emissions are covered by EU ETS or the UK's Climate Change Agreements – examples are aluminium, paper, cement and lime, food and drink, chemicals, steel
- Large non-energy-intensive users covering both low energy-intensive manufacturing large service sector firms (>50 employees in former and >250 employees in service sector)
- Public sector, covering all government estates
- SMEs defined as firms with less than 50 employees in manufacturing and 250 employees in services

7. The Oxera sector competitiveness model (used earlier in the 2004 study) is used to analyse the competitiveness effects of EU ETS and the cost impacts of overlap between EU ETS and CCA for sectors. The analysis had found that a significant driver of competitiveness was the ability to pass costs through to customers, and found that the aluminium sector (not covered by ETS but covered by CCA) to be adversely affected by the instrument whereas all other sectors could pass their costs through in the medium term, i.e. Until 2010, relatively easily while maintaining their competitiveness. For steel and cement, the scenario between 2010 and 2020 may be a cause for concern with potentially large price increases required to maintain profit.

8. The Carbon Trust acknowledges the service sector gap with regard to coverage of the Climate Change Programme with the increased use of energy and electricity in services and light industry and their potential to become significant emitters of carbon in the future. They suggest that the best policy instrument for providing incentives to less-energy-intensive sectors to reduce emissions would be through a company/organisation level, auction based, emissions trading system (UK CETS) that can address energy usage not otherwise covered by EU ETS and CCA and recycle most of the revenues back to participating sectors via CCL discounts or other means. The UK CETS is assumed to deliver substantial carbon savings without exposing companies to additional financial costs, assuming that they are provided a rebate on the Climate Change Levy on entering the scheme. The Carbon Trust believes that increased visibility of emissions combined with the auction will drive additional abatement that would not have taken place otherwise.

Berkhout et al (2003) Innovation in the Chemicals Sector and the New European Chemicals regulation and RPA with London Economics (2005) Project to Assess the Impact of the New EU Chemicals Strategy (REACH) and to Develop a Model

9. This study reviews the literature and industry funded studies examining the potential impact of REACH on innovation, competitiveness and employment, and finds that the negative impacts have been largely overstated and that insufficient account has been taken of broader social and environmental benefits. The report also presents a qualitative assessment of the REACH proposals against a number of factors influencing innovation and the characteristics of the regulation that are likely to spur innovative activity in the sector.

10. The report discusses a study by RPA (2002) that assessed the business impact of REACH on the Chemicals sector. The RPA study briefly analysed the impact of the regulation on competitiveness and attempts to link competitiveness to output by linking the costs of the regulation to the loss of low-value products. The authors of the report state that this linkage, and the analysis is general, is suspect and fraught with poorly defined data low response rates from firms and definitional issues. Nevertheless, a more recent study by RPA assesses the impact of REACH by developing an economic model using data from case studies.

11. The study identified three case studies as appropriate in terms of reflecting different types of supply chain and raising particular issues – manufacture of silicon wafers for use in semiconductors, manufacture of coated cans for food packaging and fragrances used in cosmetics and household products.

12. Data on impact in the case study supply chains were collected through consultations using a questionnaire for participating companies. Two types of economic models were developed to conduct the case study analysis – a spreadsheet model that combined compliance costs through the supply chain, and a microeconomic model to reflect the linkages between different actors based on sector characteristics. The aim was to predict the economic impacts of REACH on suppliers and to translate these to impact on downstream user sectors in terms of changes in input and end product prices. The outputs from the case study analysis enabled predictions of the likely impact of REACH at a sectoral level and according to firm size. But the microeconomic model was not applied to all three case studies as the result of the spreadsheet model indicated that REACH would not affect costs faced by downstream users significantly even if 100% of the costs were passed through.

13. The broad findings from the case studies indicated that REACH is unlikely to have a negative impact on the competitiveness of firms in the silicon wafers and can coatings case studies. The regulation may have some impact on the profitability of firms in the manufacture of fragrances. Overall, the potential annual costs of REACH to the sectors studied were relatively low.