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Working Party on National Environmental Policy

The Firm, The Environment, and Public Policy

This is the final report of the OECD's "Eco-Efficiency Project". The report brings together case studies presented by member countries, a review of the relevant secondary literature, and an empirical analysis of the relationship between firms, management systems, and environmental performance.

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Summary

During the last few years OECD countries have witnessed an increased awareness on the part of firms of the potential to realise certain commercial objectives through improved environmental performance, and an increased awareness on the part of public policy-makers of the need to understand how firms actually operate when designing and implementing environmental policy.

In recognition of these developments the OECD initiated a project on "eco-efficiency", exploring the links between environmental and commercial performance. Initial outputs included a preliminary report on the general principles of "eco-efficiency" (OECD 1998A). This report summarises the main conclusions of subsequent work on the project. Drawing upon a small number of case studies, existing secondary literature, and policy reports prepared by member countries, the report looks at the links between firm-level commercial motivations and environmental management and performance in greater depth. Insights from the literature on industrial organisation are used to cast further light on effective and efficiency of environmental policy design.

The first section of the report seeks to define and situate "eco-efficiency". It is argued that in order to be useful the term needs to be circumscribed to a greater extent than is usually done. In this report, the term is used to characterise those instances in which firms can realise commercial benefits with improved environmental performance, for reasons which are not strictly a function of regulatory conditions. In effect, the term is used to define those instances in which there are commercial-environmental synergies, holding the policy framework constant.

A precondition for reviewing conditions under which this might arise is the ability to evaluate environmental performance at the level of the firm. The second section reviews "indicators of environmental performance", paying particular attention to the means by which they can be classified (e.g. scope of the indicator, means of normalisation, degree of disaggregation, etc...) . In addition to reviewing some of the existing "indicators", the report also reviews the use to which such indicators are put.

The subsequent section examines the links between decision-making within the firm and environmental management and performance. This is a controversial area since some see significant opportunities for "win wins" (even holding policy conditions constant), while others doubt their very existence. The report seeks to explore the reasons for this divergence of views, drawing upon the literature on industrial organisation. It is argued that such opportunities (if they exist) are most usefully seen as response lags, arising from the necessarily imperfect means by which firms seek to allocate their internal resources (staff and other), introduce appropriate incentives for personnel, and filter and process relevant information.

The section also reviews the various environmental management tools and strategies which firms can implement to try and identify and act upon various environmental-commercial opportunities. A distinction is drawn between tools for analysis and evaluation, communication instruments, and human resource tools. These are means to address some of the issues discussed above, focussing specifically on environment-related tools.

This is followed by a review of the empirical evidence. Given the more usual focus on studies based upon small (non-random) samples of "environmentally-responsible firms", this section draws upon the more formal statistical analyses. The relevant literature discussed includes that which explores the relationship between firm characteristics and environmental performance, surveys of self-assessments of the relative importance of different "drivers" which are encouraging improved environmental performance, and a review of the studies which have looked at the links between environmental management and

performance. In addition, empirical evidence on the relationship between financial and commercial performance is reviewed.

Drawing upon a random-sample survey of European manufacturing firms, these issues are further explored in the subsequent section. In particular, two relationships are explored: the links between firm characteristics and the probability of having an environmental management system in place; and, the links between the presence of an environmental management system and (self-assessed) environmental performance. The most significant result from the analysis is the positive and significant relationship in the latter case.

The policy implications of the study are summarised in the next section. These are three-fold:

- Firstly, use policy instruments which increase incentives for firms to identify and act upon environmental-commercial synergies. This includes economic instruments, but also performance-based standards. In addition to the short-run benefits, this can have long-run benefits since firms will adjust their responses (organisation structures, management systems, etc...) to regulatory pressures differently depending upon the nature of the instrument used. This may lead to better decision-making more generally.
- Secondly, information-based tools can have an important role to play on both the demand-side and the supply-side. There are barriers to information for both firms and households, and such tools can help to amplify incentives for improved environmental performance, and foreshorten the responses of households and firms.
- Thirdly, public authorities may have a role to play in explicitly influencing decision-making structures within the firm. This includes incentives for self-audits, environmental reporting, accounting procedures, etc.... However, it is important to note that governments are not well-placed to dictate management systems within firms, and the implications of such policies should be examined closely.

The report concludes by stressing the need for further work in this area. OECD member country governments are increasingly seeking to "fine-tune" to better influence firms' management systems. As such, there is a clear need to understand firm-level management responses and "environmental" motivations in greater depth.

1. Introduction: Defining and Situating Eco-efficiency

The last few years have witnessed two very significant developments in the environmental area in OECD countries:

- an increased awareness on the part of firms of the potential to realise certain commercial objectives through improved environmental performance; and,
- an increased awareness on the part of public policy-makers of the need to understand how firms actually operate when designing and implementing environmental policy.

In recognition of these developments, the OECD initiated a work programme on “eco-efficiency” in 1997. (An initial output of the project was produced in 1998 (OECD 1998A), followed by report on the proceedings of a workshop held in Sydney in 1999 (OECD 1999A). In addition, a draft report (OECD 2000A) has been prepared linking case studies provided by the member countries with the broader issues related to eco-efficiency. And finally, an empirical analysis of links between environmental management and performance (OECD 2000B) has been prepared. These latter reports form the basis for much of the present document.)

The term “eco-efficiency” was first coined by the World Business Council for Sustainable Development. Although, the term has since come to mean all things to all people, in 1993 the WBCSD set out its view on what was meant by the term. (See Box 1.) The definition is exceedingly broad. While this has some advantages, it also means that it is difficult to situate the term relative to other terms used in the environmental field. For instance, the definition includes issues which are relevant at the level of the firm (the first two bullets), the entire production-consumption life cycle (the third bullet), and those which only have significance at a global level (the fourth bullet).

Box 1. WBCSD definition of “Eco-Efficiency”

“Eco-efficiency is reached by

- the delivery of competitively-priced goods and services
- that satisfy human needs and bring quality of life,
- while progressively reducing ecological impacts and resource intensity throughout the life cycle,
- to a level at least in line with the earth’s estimated carrying capacity.”

(WBCSD, 1993)

Although the focus has been mainly on material and energy use, pollution emissions and waste generation at the level of the individual firm, the definition also emphasises broader social objectives and environmental constraints. Nonetheless, most of the examples of “eco-efficiency” identified by the WBCSD, World Resources Institute, and others are initiatives by individual firms. (See Five Winds International 2000 for an overview.) According to WBCSD (1993) a company wanting to become eco-efficient should strive to:

- reduce the material intensity of its goods and services
- reduce the energy intensity of its goods and services

- reduce the dispersion of any toxic materials
- enhance the recyclability of its materials
- maximise the sustainable use of renewable resources
- extend the durability of its products
- increase the service intensity of its goods and services

The realisation of multiple (potentially conflicting) objectives raises a number of problems, some of which are discussed below. However, rather than re-entering debates on the scope of the term in terms of environmental impacts, this paper starts from the premise that “eco-efficient” initiatives are all those measures that are undertaken by firms which have significant positive environmental consequences and which also generate commercial benefits.

1.1 Eco-Efficiency and Environmental-Commercial Opportunities

Using this starting-point, the interest in “eco-efficiency” can be at least partly understood as a reflection of the increasing number of reported “win-win” cases, in which environmental and commercial incentives are seen to be complementary. Thus, it is argued that firms are improving their environmental performance because it is in their commercial interest to do so, even if regulations are not made more stringent.

However, it is often difficult to distinguish between motivations. Indeed, at heart all motivations for the firm are commercial. Even the degree to which firms comply with direct forms of regulation is a financial decision, dependent upon factors such as penalties for non-compliance, probability of enforcement, and loss of reputation. Thus, firms are motivated by a combination of factors. For instance, firms may reduce their emissions of toxics because they do not want to be perceived as “polluters” by their customers, because their investors are concerned about potential future liability claims, and because regulators are requiring improved environmental performance. In this example, all three factors have “financial” motivations, but the latter two arise directly out of government policy, while the former may not.¹

Distinguishing between regulatory and commercial motivations is, therefore, not always a helpful way to view the relationship between policy design and firm-level decision-making. There can be win-wins irrespective of the nature of the regulatory environment. The key point is whether or not firms are recognising such opportunities (if they exist) given the existing regulatory environment. Thus, win-wins are those initiatives in which firms recognise and act upon environmental concerns which have positive commercial consequences, holding external incentives (regulatory and other) constant.

Moreover, the “commercial” interest of the firm has to be understood broadly. It is increasingly clear that firms are motivated by a number of rather nebulous and intangible factors which can not be easily reduced to financial analyses of alternative investments in production processes and product development. Factors such as the reputation of the firm, the subjective motivations of managers, and long-

¹ Although it may be supported by government policy indirectly – eg. through information-based measures which increase the “credibility” of environmental branding.

run risks need to be taken into account. (See Kestemont and Ytterhus 1997 for a discussion.) While some of these are key to the long-run sustainability of the firm, they are not always adequately reflected in discussions of the firm's incentives.

1.2 Public Goods and Private Incentives

Does the belief in eco-efficiency mean that private firms can be relied upon to protect public environmental goods? Clearly, it means that when given the opportunity firms will exploit commercial opportunities with environmental benefits. However, it is important to be careful about the place of such opportunities in the context of the broader social objective of bringing about general improvements in environmental quality. This needs to be understood on both the demand side and the supply side, reflecting the sources mentioned above through which "win-wins" can arise.

This is best done by classifying potential opportunities, distinguishing between the nature of the links between marketed goods and services and environmental impacts. Such impacts arise due to the "public good" nature of environmental resources. Public goods are goods in which it is not feasible to prevent people from consuming the resource or being exposed to its degradation (non-excludability) and where one individual's level of consumption does not affect another individual's consumption possibilities (non-rivalrous). In practice, there are very few "pure" public goods. However, all environmental problems arise from conditions under which these characteristics prevail to one extent or another.

Firstly, environmental-commercial opportunities may arise in cases wherein there is a close link between the use of commercial resource input which has close links to a threatened public environmental good, and the firm is not using the resource input efficiently at prevailing prices. Examples include increased efficiency in the use of fossil fuels (potentially reducing greenhouse gas emissions and associated air pollutants), process water (potentially protecting aquatic ecosystems and fish stocks) wood fibre (potentially conserving natural forest habitats). By using the resource more efficiently the firm will drive down its costs of production and protect scarce natural resources and environmental quality.

Secondly, such opportunities may arise in cases where the firm is able to sell its products on the basis of the customer's use of marketed inputs which have close links to threatened public environmental goods. Most obviously this relates to energy-saving and water-saving consumer durables and capital equipment, with similar environmental benefits to those discussed above. In this case the firm is able to capture market share (commercial benefits) by selling its products on the basis of the lifetime financial costs of the good for the customer.

Thirdly, they may arise in cases where the firm is able to "embed" the value which the customer attaches to the public environmental good directly in the product ("differentiation") or for the firm as a whole ("branding"), even though the product remains functionally identical. In this case the firm would be using the environmental characteristics of its production process to market a good, which is indistinguishable from competitors' goods in every other sense. In this case the firm is able to capture market share. Unlike in the previous case the firm may also be able to capture rents, at least in the short term.

Fourthly, they may arise in cases where there is a close link between the effects of the production process on public environmental goods and non-financial attributes of the product which are valued by customers. The example of organic agriculture is illustrative. On the one hand, through reduced chemical pesticide and fertiliser use it may reduce runoff of water pollution, protecting public environmental goods.

On the other hand, it may result in a product which is more highly-valued by the consumer (e.g. for nutritional reasons), irrespective of concerns about the public environmental benefits.²

Table 1: Classification of Types of “Win-Win”

	No change in functional attributes of product	Change in functional attributes of product
Cost	Through change in production process firm is able to increase efficiency of use commercial resource inputs, reducing costs and protecting public environmental goods associated with the input. (Example – reuse of cooling water.)	Through product redesign firm is able to reduce lifetime costs by increasing efficiency in the use of a commercial input for the durable, generating financial savings for the customer and protecting associated public environmental goods. (Example – energy-efficient water boiler.)
Quality	Through an environmentally beneficial change in production process the firm is able to differentiate its product even though the functional attributes of the product are identical, increasing market share and capturing rents. (Example – CFC free refrigerator.)	Through environmentally beneficial change in production process, the firm is able to differentiate its products on basis of associated non-financial personal preferences. (Example – organic agriculture.)

These four cases are summarised in Table 1, distinguishing between whether or not the commercial benefits are achieved primarily through cost reductions or quality changes, and whether or not there is a change in the functional attributes of the product. However, there are two important points to bear in mind. Firstly, in the absence of external incentives which protect the public good directly, private incentives (on the part of the firm and/or the consumer) will never be sufficient to protect the public good entirely. Secondly, all of these cases are dependent upon the assumption that private firms have not been exploiting commercial opportunities under existing market conditions. This report will explore these issues in detail.

1.3 Structure of the Report

In exploring these issues, the report draws heavily upon a number of case studies, as well as other relevant literature. Section 2 reviews the literature on indicators of environmental performance at the level of the firm. Section 3 discusses firm-level barriers to the realisation of environment-commercial opportunities, and the means the firm can use to identify and act upon these opportunities. In Section 4, the empirical evidence related to the links between firm characteristics, management systems, environmental performance, and commercial performance is reviewed. This is supported in Section 5 with some further analysis undertaken by the Secretariat, based upon a survey of over 2,000 European manufacturing firms.

However, perhaps, the most important purpose of this report is to determine if the existence of commercial-environmental opportunities has implications for public policy, and these issues are discussed in Section 6. Should governments intervene in order to encourage firms to do what is (apparently) in their own interest? And if so, what policies can effectively and efficiently increase the “elasticity” of response of firms? This section is, therefore, concerned more with the policies which increase the internal responsiveness of firms to commercial-environmental opportunities, rather than with policies which affect

2. Some literature mentions the potential for reduced liabilities due to lower environmental damages. (See WBCSD 1995.) However, liability regimes are best understood as complements to the regulatory system, and as such will not be discussed in the context of this report. Another factor which is commonly discussed in the economic literature: strategic behaviour to influence regulatory authorities. For instance, this might be motivated by a belief that such initiatives will preempt or weaken proposed regulations, encourage governments to reduce monitoring effort, or serve as a signal to persuade regulators to introduce policies which raise rivals’ costs. See Lyon and Maxwell (1999) and Karl and Orwat (2000).

the external incentives generated by regulatory systems. It draws upon a set of case studies that were prepared by selected member country governments as well secondary literature. The report concludes with a summary of the main lessons learned.

2. Indicators of Environmental Performance at the Level of the Firm

It is important to first review the alternative means of evaluating environmental performance at the firm-level. An indicator is a variable defined through measurement or observation. The variable is chosen such that it is able to convey information on the condition (and/or trend) of some characteristic of the system which is of interest. (See Gallopín 1997.) However this characteristic is not usually directly observable, and thus the variable chosen is a proxy for the characteristic itself. This makes interpretation of the indicator crucially important.

2.1 *Classifications of Indicators*

In the area of environmental performance, developing indicators has been a fraught exercise, with proposals coming forth from firms, academics, NGO's and government agencies. (See German Federal Environmental Ministry/German EPA 1997, Tyteca 1994, Lehni 1998, NRTEE 1999, and Müller and Sturm 2000 for reviews.) In general, most indicators take the form of a ratio of "environmental" inputs over economic outputs. In some cases they are the inverse. They are, therefore, indicators of either the efficiency with which environmental inputs (resource use and waste sinks) are used, or (equivalently) environmental factor productivity. However, the means by which this ratio is derived are manifold, all of which have different advantages and disadvantages.

In the first instance, it is clear that the "scope" of the indicator is important. It can relate to the production process, plant, firm, product, industrial sector, or national economy. Since this paper is concerned with the business-level decision-making, we will concentrate on those indicators associated with the production process, the plant, the firm and the product. The firm is, of course, the most common frame of reference since this is the basic decision-making unit. It is also usually the easiest for which to obtain data. However, firms are increasingly heterogeneous in nature which complicates comparison between firms. For instance, through horizontal integration individual firms produce an increasingly wide variety of goods and services (with different sectoral classifications). Moreover, the product mix can change through time, resulting in incommensurable results over time. In a report prepared by the Canadian Round Table on the Economy and the Environment (NRTEE 1999), two firms (Procter and Gamble and 3M) cited this as a major factor in undermining the usefulness of some firm-level indicators.

In environmental terms, the product (life-cycle assessment) may be the most appropriate frame of reference. However, except in cases where there is a high degree of vertical integration (e.g. petroleum extraction, refining and distribution) this involves the collection of data across a number of different firms. The development of indicators at the level of the plant or the production process is much simpler. However, in both cases this may fail to capture substitution effects: increased efficiency at a discrete stage of production may reflect reduced efficiency at other stages of production. This is particularly true at the level of the individual production process.³ Moreover, it may be difficult to accurately allocate figures for both the environmental numerator and the economic denominator at the level of the product or process.

Secondly, the "nature" of the indicator is important. In general a distinction can be drawn between "management" indicators, "performance" indicators, "pressure" indicators and "impact"

3. At the level of the plant reduced efficiency may be reflected in reduced value of outputs, thus changing both the numerator and the denominator.

indicators. Management indicators are those which seek to reflect the effort which goes toward improving environmental performance. Common measures are personnel hours devoted to environmental concerns, existence of environmental management systems, extent of environmental reporting, etc..... While useful, these indicators are indirect. They assume that the indicator is a good reflection of effort, and that effort is positively correlated with performance. Both links may not hold up well – an issue which is explored below. However, they are easily derived and commonly available.

The latter three types of indicators (“performance”, “pressure” and “impact”) are physical in nature, but differ according to their conceptual proximity to environmental damages. Thus, looking at fossil fuel combustion, examples of the three would be fuel efficiency (“performance”), greenhouse gas emissions (“pressure”), and global warming potential (“impact”).⁴ Analogously, there might be indicators of water efficiency (“performance”), wastewater emissions (“pressure”), and BOD (“impact”). Use of impact indicators is generally preferable, but data availability for most environmental concerns is not readily available and may not even be pertinent at the level of the firm, plant or production process.⁵ For instance, in order to determine the environmental impacts of sulphur dioxide emissions it is important to know the plume of emissions from the plant (and all other plants in the relevant region) and the critical load of the receiving environment. As such, “pressure” indicators (emissions) or “performance” indicators (energy efficiency) are more likely to be used.

The third relevant feature of indicators is the degree of “**disaggregation**” of environmental impacts. In this case there is a trade-off between highly disaggregated indicators and aggregated indicators. On the one hand disaggregated indicators (e.g. primary wood fibre use in pulp and paper plants) may mask potential substitution effects between alternative resource inputs and even between resources and pollutants. Thus, an improvement in one particular indicator may merely be a reflection of increased impacts of another sort. (For empirical evidence of examples of such substitution effects for fossil-fuel fired electricity generation plants see Färe, Grosskopf and Tyteca 1996. This issue is also discussed in NRTEE 1999.) This problem becomes particularly acute for synergistic pollutants.

On the other hand, aggregated indicators may necessitate the use of numeraires which have little environmental significance. For instance, in order to make alternative material inputs commensurable WRI (1997) uses tons as the numeraire. This is clearly unsatisfactory. (For a critical review see SEPA (2000). In later reports WRI (2000a) further declassifies material use into broad categories based on their environmental characteristics.) This issue is particularly problematic if relatively “benign” material use dominates material inputs measured by mass. The case of water is discussed in NRTEE (1999). However, some aggregate indicators can be derived when the impacts are environmentally commensurable in a fairly predictable manner. For instance the use of TSS, BOD, pH are examples. More controversially, efforts have been made to weight toxic emissions on the basis of results from epidemiological studies, which look at toxicity, sometimes weighted by persistence and bio-accumulation.⁶

In order to overcome this trade-off between aggregated and disaggregated indicators, many have advocated the use of a vector of disaggregated indicators. (See OECD 1998A and NRTEE 1999.) However, even in this case the problem of incommensurability will arise. If individual indicators are

-
4. Analogously on the resource use side, three examples from forestry might be timber yields (performance), percentage primary forest exploitation (pressure), and biodiversity loss (impact).
 5. Global warming is one of the few cases where, for most sectors, all three types of indicators are easily and readily derived. In other cases where pollutants have location-specific or time-specific effects, are synergistic with other pollutants, or have non-linear damage functions, the task is well beyond the firm.
 6. See Hettige et al. (1994) and NRTEE (1999) for discussions. At a more fundamental level, there are debates about whether indicators should reflect toxicity to humans or to ecosystems.

moving in opposite directions, there is no way to evaluate whether or not this represents an improvement or deterioration in the firm's performance.⁷ Since this is likely to be very common, particularly as the list of indicators included in the vector expands (and thus potential for substitution effects to be reflected), such concerns are by no means incidental.

Fourthly, indicators may also be **“relative” or “absolute”** in nature. “Relative” indicators are those which compare an absolute figure with some benchmark. The benchmark may be derived from environmental standards, the best prevailing environmental performance, or a theoretically optimal performance. Relative indicators are usually expressed as an index, a score or a ratio. Conversely, absolute indicators are just the raw data (e.g. pollution emissions, resource use, etc....), used as the variable to reflect the state of some environmental attribute. (See German Federal Ministry of the Environment/German EPA 1997.)

Relative indicators are generally preferable insofar as results are more easily comparable. However, it is important that the means used to “relativise” the absolute figure is appropriate. For instance, environmental standards should only be used to assess the performance for firms which are similar in nature. Indeed, in some senses the distinction between absolute and relative indicators is really just between indicators which incorporate comparisons *ex ante* and those which necessitate comparison *ex post* by the users. It may be preferable to let the users themselves decide how to adjust the absolute figures, particularly since different means of relativising figures will be appropriate for different uses.

In addition, it is important to distinguish between different types of economic output data which are used to **“normalise”** the environmental input figures. In general monetary figures are used, although in some rare cases physical output data (e.g. tons or units) are used. The latter are only likely to be useful for cases where outputs are homogeneous across firms and across time. This implies that they are only useful for commodities at a very low level of disaggregation and for very short periods of time. In other cases they will not be comparing like with like and the results may be misleading.⁸

Even the choice of monetary figure used for normalisation can be significant. For instance, depending upon the scope of the indicator the difference between using value-added and value of shipments can be very great. (See Müller and Sturm 2000.) Thus, use of value of shipments for an indicator which only covers a single stage of production, a plant, or even a firm will not be very reliable since most of the value may be a function of the value of intermediate inputs. However, if the environmental numerator embodies upstream stages of production (e.g. material inputs), then use of value of shipments may be more appropriate even for firm-level or process-level indicators. More generally, if the indicator relates to the product (life cycle) it is important to use the value of shipments at the final stage of production (the retail end). And finally, some other studies use employment levels, but this is of dubious quality if relative factor input ratios vary widely across the units compared.⁹

7. Unless, one resorts to estimates of environmental damages from valuation studies, a course which few of the proponents of “eco-efficiency” indicators seem to be willing to follow.

8. The authors of the NRTEE (1999) report assert that physical data may be helpful in cases where inflation and exchange rate fluctuations affect the reliability of monetary data. However, the first issue can be easily addressed through the use of appropriate (sectorally disaggregated) deflators. Exchange rate fluctuations are only relevant for comparisons of firms across countries. Moreover, even in this case the use of purchasing-power-parity figures will address this concern.

9. The correlations between the indices of toxic intensity normalised by employment and value added in the IPPS study (Hettige et al. 1994) is just 0.82. The figures for value of shipments and value added (0.93) for employment and value of shipments (0.92) are much higher.

2.2 *Examples of Indicators*

Despite these methodological problems, considerable effort has been made recently to develop such indicators for use by firms. WBCSD itself has a project on “eco-efficiency metrics”, which has advanced thinking among its member companies on the range of data that might be collected as indicators of eco-efficiency. The Canadian NRTEE has held a series of workshops to develop eco-efficiency indicators for use by firms. The European Environment Agency has also begun to evaluate possible eco-efficiency indicators for use at a macro level. WBCSD and NRTEE have developed very long lists of possible eco-efficiency indicators.

Some of the indicators proposed can be reviewed on the basis of methodological concerns set out above. In their study of firms from three industries (pulp and paper; steel, metals and mines; and chemicals and oil refineries) Cormier et al (1993) derive a pollution performance index. The index is a relative figure, based upon the ratio of actual emissions relative to regulatory standards. The index is reported at the level of the firm, but it is derived from plant-level figures which are weighted by water flow-through. Two different “representative” pollution measures are used for the different sectors: BOD for pulp and paper and TSS for the other sectors.

In a study of toxic emissions in the United States Martin et al. (1991) use an aggregate indicator based upon toxicity weights. Thus emissions of various pollutants are weighted according to the health-related weights used in TRI. (See Hettige et al 1994 for a discussion of the weighting system used.) This gives a total pollutant risk which is then normalised using values of shipments. The indicator is applied at the level of the plant, firm or even industrial sector.

For pulp and paper plants Jaggi and Freedman (1992) derived a combined indicator of BOD, TSS and pH. The BOD and TSS factors are expressed relative to values for “clean” water and normalised by tons produced. The pH indicators are expressed as deviations relative to pH-neutral water (e.g. pH range from 6.0 to 8.5). Pipe-level values are summed across plants and then firms. The three values are standardised relative to the largest observed values in the sample and then summed to yield an overall indicator. Implicitly this “values” the three pollutants equivalently.

There have also been a number of company initiatives. According to Lehni (1998) Sony uses a much simpler firm-level indicator. Value added is multiplied by estimated product life and divided by the sum of material use (consumption minus recycling) and energy. In this case, an increased value would reflect greater “eco-efficiency”. However, while simple this indicator is potentially misleading. Firstly, the numerator would incorporate some double-counting since increased durability implies increased value added (if it is valued by consumers). Secondly, the denominator has incommensurable units (e.g. tons and joules).

Even simpler, Landis and Gyr use separate indicators for total energy, potable water and non-recycled waste generation. These are normalised at the firm-level by value added and/or the number of employees. According to Müller and Sturm (2000), Sulzer and Roche both use similar indicators. However, based upon the pressure data Landis and Gyr also derive indicators for global warming potential, acid rain, smog creation and ozone depletion potential. Dow use a scoring system in which six dimensions (mass intensity, human health and environmental risk potential, energy intensity, reuse, conservation of resources and extent of service function) are rated (by the firm) from zero to five.

And finally, a number of organisations have sought to derive process-related indicators. For instance, the Canadian Institute of Chartered Accountants derives indicators bases upon environmental management issues, environmental expenditures, compliance situation and other factors. Similarly the Coalition for Environmentally Responsible Economies looks at materials policy, waste management

systems, supplier relations, product stewardship and other factors. Table 2 summarises the characteristics of various indicators using the criteria developed above.

2.3 Use (and Usefulness) of Indicators

Which indicators do firms actually use? A WRI-Tellus Institute survey of 33 environmental managers in the United States found that the most common indicators used were: chemical releases, regulatory compliance, environmental spending, water use, greenhouse gases, energy use, chemical inputs and chemical use efficiency. (Ditz and Ranganathan 1997.) The results are hardly surprising. Chemical releases and regulatory compliance information are both mandatory. Similarly, firms used to have to report environmental spending data in the *Pollution Abatement Costs and Expenditures* survey. Water use, energy use, and chemical inputs are all readily derived from company accounts.

Table 2: Examples and Types of Eco-efficiency Indicators

	<i>Scope</i>	<i>Nature</i>	<i>Degree of Aggregation</i>	<i>Relative and Absolute</i>	<i>Values Used for Normalisation</i>
Cormier et al (1993)	Firm (based upon process)	Pressure	Disaggregate (BOD, TSS)	Relative to Standard	Water Flow-Through
Martin et al (1991)	Firm (based on plants)	Impact	Somewhat aggregated (toxicity wrt human health)	Absolute	Value of Shipments
Jaggi and Freedman (1992)	Plant, Firm, Sector	Pressure	Somewhat aggregated (overall water pollution index based upon BOD, TSS and pH)	Relative to Largest Reported Values	Tons Produced
Sony	Firm	Pressure	Very aggregated (e.g. material and energy use)	Absolute	Value Added (and Product Life)
Landis and Gyr	Firm, Subsidiary	Performance (energy use, water use) Pressure (acid rain emissions), Impact (GWP)	Very aggregated (e.g. energy use) or somewhat aggregated (e.g. smog generation)	Absolute	Value Added and Employees
Dow	Firm, Subsidiary	Performance	Very aggregate (e.g. material intensity)	Relative (self-assessed scoring system)	NA
CICA	Firm, Subsidiary	Management	NA	Absolute (Discrete Response)	NA
CERES	Firm, Subsidiary	Management	NA	Absolute (Discrete Response)	NA

Whether or not these indicators are useful depends upon how they are interpreted and used within the firm. The German Environment Ministry/German Environment Agency (1997) has developed a set of six principles for indicators of corporate environmental performance. A number of these highlight the importance of ensuring that indicators can be used by the firm in its own operations. (See Box 2.)

Box 2. Basic Principles of Indicators of Corporate Environmental Performance

The following basic principles apply to establishing a corporate environmental indicator system:

A. Comparability—The indicators must allow comparisons to be made and must reflect changes of environmental impacts.

B. Target Orientation—The selected indicators should pursue improvement goals that can be influenced by the company.

C. Balance—The indicators must represent the environmental performance as accurately as possible and provide a balanced illustration of environmental problem areas as well as improvement potentials.

D. Continuity— In order to compare indicators, it is essential that they are established with the same data collection criteria in very period, that they refer to comparable intervals, and that they are measured in comparable units.

E. Timelines— The indicators should be determined in short enough intervals (e.g. monthly, quarterly, annually) in order to have the opportunity of actively pursuing and influencing the achievement of target figures, and to avoid providing outdated information.

F. Clarity— The indicators must be clear and comprehensible for the user and correspond to the user's information requirements. The system should therefore be coherent and concentrate on essential data.

Source: German Environment Ministry/German Environment Agency (1997)

3. Firm Decision-Making and Environmental Management Tools

In this section, attention will be paid to the obstacles which firms face in identifying and acting upon environmental-commercial opportunities and the tools that firms can apply in order to overcome some of these obstacles. This goes to the heart of debates about “win wins”. On the one hand, much of the business literature supports the view that there are numerous unrealised commercial opportunities with environmental benefits, while on the other hand most economists reject the view that such opportunities can be sufficiently widespread to warrant much attention on the part of policymakers. (See Porter and van der Linde 1995 and Palmer et al. 1995 for discussions.)

Indeed, reviewing the business literature it is sometimes astonishing how many apparently profitable opportunities with positive environmental consequences have been left unexploited. It will be argued that organisational structure and decision-making procedures can affect the ability of firms to identify and act upon commercial-environmental opportunities. In some cases, organisational structures may be “barriers” to the identification of such opportunities. However they also yield other benefits, such as filtering of information and improved control of operations. There is a trade-off. At some stage, the costs of lost opportunities may exceed the benefits generated by organisational structures and operating procedures. In this context, many firms are introducing a number of tools and strategies to try and identify commercial-environmental opportunities and overcome some of the organisational barriers which exist in a more timely manner.

3.1 Organisational “Failure” and Environmental-Commercial Opportunities

Recent discussions about the importance of environmental-commercial “win-wins” imply that firms do not appear to be “profit-maximisers” in the area of environmental management and investment. (See DeCanio and Watkins 1998 for a review of the empirical evidence in the area of energy efficiency.) In particular, it is argued that firms are not always able to spot and act upon a number of apparently profitable opportunities which result in improved environmental performance. Thus, resources are not

being allocated within the firm efficiently, resulting in excessive environmental impacts. Why might this be the case?

It is clear that recognising and acting upon commercial-environmental opportunities incurs costs. Many of these costs are difficult to perceive, let alone quantify. For instance, there is a cost associated with collecting and interpreting information, including environment-related information. Moreover, even if the information is generated and understood within the firm, there may be significant "hidden costs" associated with acting upon the information. In the face of limited resources (financial, time, etc...) managers develop operating procedures which allow them to exercise control effectively over activities within the firm.

The development of such operating procedures allows firms to "filter" information and to act upon the information at minimum cost. These are important benefits, but it must be recognised that these procedures may prevent the identification and realisation of certain opportunities. There is a trade-off, and how firms balance this trade-off can be understood with particular reference to project evaluation. (See Boyd 1998 for a discussion.) A clearer understanding of these issues goes a long way toward explaining why apparent "win wins" are not acted upon.

Firstly, when evaluating which projects have positive rates of return it is important to bear in mind what meant by the "cost of capital". Contrary to many financial analyses of firm-level "environmental" projects the relevant cost of capital for the firm is not the market rate of interest, but rather the "opportunity cost of using the capital for this project versus using it for some other equivalent project". (Boyd 1998) An equivalent project is one which bears the same risk. And since evaluating "risk" is subjective, there is considerable uncertainty about what is the real underlying cost of capital, particularly when future demand conditions are unknown and investments are "irreversible". "Rules of thumb" are used in order to limit the amount of information required to evaluate whether a project is worth undertaking.

Secondly, most firms use capital rationing systems. Thus, rather than allowing individual units to undertake all projects with returns in excess of the "cost of capital", corporate headquarters usually set limits on investment funds. This is done in order to ensure that managers do not overinvest by overstating the potential benefits. Such a strategy is quite likely in the presence of uncertainty and diffuse information, and where managers have incentives to expand their divisions. (See Hölmstrom and Costa 1986 for a discussion.) Thus, capital rationing is a (imperfect) way of aligning personal incentives with the firm's overall incentives. However, it means that some projects with positive returns are not undertaken.

And finally, many firms focus their efforts in the area of cost reductions on more "significant" costs (e.g. labour costs) or strategic investments on the demand-side (e.g. product development). Therefore, even if the rate of return is potentially higher in other areas, firms may not bother to generate the necessary information to discover and act upon this information. Since there are economies of scale in the identification of opportunities and transaction costs associated with acting upon them, it may be efficient to focus efforts on larger projects.¹⁰

All of these points hold true for all types of investments and not just those with environment-commercial synergies. Many projects with apparently positive returns are not undertaken and this may include some investments with environmental-commercial synergies. However, there is no reason to

10. Interestingly, this view dates from Alfred Marshall (1922) and the law of "the importance of being unimportant". He argued that inputs with small factor shares would have inelastic demand curves due to the transaction and administration costs associated with adjusting their shares. Thanks to Ken Ruffing and Gene McGlynn for reminding me of Marshall's four "laws" of the demand determination.

expect that such investments are specifically disadvantaged. Nonetheless, if funds are explicitly biased away from divisions most likely to be responsible for such investments through rationing systems, or are perceived to be inherently riskier, or tend to involve a small number of diffuse projects throughout the firm then environment-commercial synergies may be overlooked. Further work is needed to evaluate whether or not this is the case. However, a systematic review of projects in three firms (Dow, Monsanto and DuPont) did not find any evidence that firms were failing to act upon environmental opportunities which were in their own interest. (Boyd 1998).

Indeed, the vast majority of economists doubt the very existence of “win-wins”, arguing that factors such as information costs are not always recognised by those who trumpet their importance. (See Boyd 1998) In addition the implications of the need for firms to introduce operating procedures in order to align incentives within the firm are not always recognised. (See Gabel and Sinclair-Desgagne 1993) And finally, the degree of risk and uncertainty (as well as irreversibility) associated with particular investments are also not always recognised and understood. (See Dixit and Pindyck 1994). Thus, a comparison of simple financial rates of return calculated *ex ante* for different projects (as is usually done in studies which identify win wins) is not a good guide to whether or not individual firms are exploiting their resources most efficiently.

Rather than review these debates in any depth, for this report it is sufficient to point out that it often takes time for firms to adjust to changing conditions. There is, therefore, a degree of inertia associated with organisational structures. As noted this is a reflection of the need to focus information, responsibilities and effort within the firm, but at some point the costs (in terms of lost commercial opportunities) may exceed the benefits (in terms of efficient internal resource allocation). Information which is of value to the firm is not being generated and acted upon. Thus, at some point organisational procedures and structures may themselves become barriers to the recognition and realisation of profitable opportunities, including those with positive environmental consequences. (See Gabel and Sinclair-Desgagné 1999.)

In particular it is often argued that links between those parts of the organisation which are concerned with environmental (and health and safety) concerns are not effectively integrated with the rest of the organisation. Shelton and Shopley (1997) refer to this as the “green wall” and cite a number of implications of this barrier, amongst which is the reduction in the capacity to recognise and act upon environmental-commercial strategies. Perhaps the most straightforward (and potentially important) manifestation of this problem relates to cases in which responsibilities for capital and operating costs associated with energy-related investments are divided between cost centres within firms. (See Jaffe *et al.* 2000.) In such cases, there will be disincentives for investments in costly energy-saving equipment, which has lower life-cycle costs. However, the problem can take much more subtle forms.

The nature of the relationship between managers and employees (and between levels of management) may also be a source of apparent non-optimisation. There is a trade-off between the benefits of “control” over employees behaviour and the benefits of allowing employees the “initiative” to recognise and act upon information which may lead to commercial-environmental synergies. Since shop-floor employees are often those best-placed to recognise such opportunities (particularly on the cost side), excessive control may result in lost opportunities. (See USOTA 1994.) Indeed, unless the employee has appropriate incentives (e.g. financial remuneration, performance review, etc...) they may not transfer information about even the most obvious opportunities. (See ELI 1999)

In summary, the identification of “win wins” must be based upon a proper understanding of the means by which firms evaluate alternative investments. There are costs associated with identifying and acting upon commercial-environmental synergies. However, at some point the systems used to “filter” information and structure responses to such information may not be appropriate. How quickly firms

respond to this dysfunctionality is important. Evaluating whether or not such dysfunctionalities are more prevalent in the environmental area is beyond the scope of this report. However, it is possible that the changing nature of environmental concerns and the uncertainty of costs and benefits in the area (not least because of the importance of public policy frameworks) mean that there is a greater tendency to miss opportunities in this area.

3.2 *Environmental Strategies and Management Systems*

In light of apparent environmental-commercial opportunities, firms have been introducing management strategies, systems and tools which assist them in identifying such opportunities.¹¹ However, developing environmental strategies, management systems and tools has been a difficult exercise, with a myriad of proposals coming forth. Thus, there is not always a clear understanding of the terminology.

Improved environmental performance is the overall environmental objective or strategy. (This is often referred to as "cleaner production".) In order to implement this strategy a firm applies a management system. The management system should incorporate a review of the environmental effects generated by a company, the preparation of an environmental policy designed to ameliorate the identified effects, and the implementation of procedures to achieve the aims and objectives of the policy. (See UNEP 1995.) Depending upon differing management structures, product markets, production processes, firm priorities, and internal and external financial and political factors, every firm will have an individual approach to the development of an EMS.

However, a general definition is provided by the International Standards Organisation (ISO). They define an EMS as: "...that part of the overall management system which includes organisational structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing and maintaining the environmental policy." (See <http://www.iso.org> for details.) While there is no set list of components of an EMS, it should include at least the following elements:

- a definition of the corporate environmental policy;
- the development of an strategic action plan;
- the definition of environmental responsibilities within the firm;
- the development of internal training and information courses; and
- regular monitoring and improvement of the system.

Applied effectively the use of an EMS should help firms to:

- raise awareness of environmental issues amongst all staff within the company;
- motivate employees to search for creative ways to reduce environmental costs;
- assess managers in targeting cost reduction, improving environmental quality and in reinforcing quality principles;
- encourage changes in processes to reduce waste, reduce resource use, recycle waste or identify markets for waste; and,
- identify new market opportunities for environmentally-preferable products.

EMS is a voluntary strategy. Thus, there is no obligation for the firm to implement an EMS. This voluntary character is reflected in the importance of the individual firm's definition of the corporate environmental policy which underpins the EMS and the commitment of the management and the

11: Sub-sections 3.2 and 3.3 and Appendix 1 were prepared in collaboration with Mr. Peter Aertker.

personnel. It is in the hand of the management to define the speed and the comprehensiveness of the introduction of an EMS. Moreover, there is often a gap between what companies aspire to and what they achieve in the long term. Reviews alone cannot provide a firm with the assurance that its performance not only meets but also continues to meet corporate policy requirement. (Welford 1999) However, a sound application of an EMS will encourage firms to examine their environmental performance and to find creative ways to exploit environmental-commercial opportunities. (Table 3 gives figures for EMAS and ISO 14001 certification in selected OECD countries.)

Table 3: EMAS and ISO 14001 Certification for Selected OECD Countries

	EMAS	ISO 14001
UK	70	800
Sweden	153	520
Spain	30	175
Norway	52	72
Netherlands	22	400
Italy	14	120
Ireland	6	82
Germany	2020	1300
France	32	238
Finland	18	160
Denmark	99	350
Austria	175	200
USA	NA	450
Taiwan	NA	423
Switzerland	NA	259
Korea	NA	263
Japan	NA	2043

Source: Freimann (2000)

As noted above, the management system can incorporate a variety of elements. Which elements (instruments or tools) which are included in the EMS will depend upon the individual firm. UNEP defines environmental tools and instruments as “structured or systematic instruments for improving decision-making or information management or for effecting changes in the behaviour of others, with the overall aim of improving the environmental performance of industry”(See UNEP 1995). Environmental management tools can be roughly divided into three groups:

- Tools for analysis and evaluation;
- Human resource tools; and
- Tools as communication instruments

These classifications are used to discuss the relevant environmental management tools in greater detail in the sub-section below.

3.3 Specific Environmental Management Tools

Using the classification set out above (analysis and evaluation tools, human resource tools, and communication tools) the different clusters of environmental management tools will now be discussed in greater detail. (See German Environment Ministry/German Environment Agency 1997, EC 2000.)

Box 3. Nortel's Green Telephone Project

A project to analyse the material, energy and environmental aspects of the telephone was carried out jointly between Nortel Networks and Environment Canada. The objective was to analyse the potential economic and environmental benefits of emerging environmental management concepts such as product life cycle assessment (LCA) and design-for-environment (DFE). Using the Nortel Networks M7310 Business Telephone as the functional unit, the study considered a number of potential improvements, including new keypad technology, thin-walled plastic housing and alternative end-of-life options. The indicators used to determine environmental impacts were global warming potential, raw material depletion potential, ozone depletion potential, acidification potential and eutrophication potential.

The project found that in the manufacturing stage integrated circuit manufacturing ranks first in terms of environmental impacts. What is surprising is that it often dwarfs the impacts from the manufacture of other components on which LCA/DFE has traditionally placed an emphasis (such as plastic or metal housing, packaging, surface treatments, etc.). Contrary to expectations, the proposed new keypad technology and thin-walled housing did not significantly affect the total life cycle impact for all of the impact categories and inventory flows.

Through electricity consumption, the use phase of electronic products is often a key contributor to environmental impacts. As such there are potential environmental gains from design features that "power-down" electronic products when they are not in use, use lower-power integrated circuit technology, new design architectures, and power factor-correction techniques.

Source: Nortel Networks/Environment Canada (2000).

3.3.1 Tools for Analysis and Evaluation

Most environmental management tools used by industry are those for analysis and evaluation. This cluster contains tools like life-cycle assessment, environmental auditing and environmental accounting. Such measures can help a firm to identify production inefficiencies, potential liabilities, and market opportunities.

Thus, LCA allows for the assessment of the potential environmental impacts throughout the product's life (i.e. cradle- to-grave) from raw materials acquisition through production, use and disposal. The general categories of environmental impacts needing consideration include resource use, human health, and ecological consequences. Although, this definition is quite broad it provides a general understanding of what is meant by LCA. *Life Cycle Assessment (LCA)*

Life cycle assessment, which is sometimes referred to as life cycle analysis or cradle-to-grave-assessment, is an environmental management tool that has evolved very quickly in recent years.¹² In 1991 The Society of Environmental Toxicology and Chemistry (SETAC) described LCA as a holistic process associated with a product, process, or activity (SETAC 1993). More recently, the International Standardisation Organisation (ISO) has published a definition of LCA focusing on products or a function of a product. This definition, which has become the norm, spells out three key elements. "LCA is a technique for assessing the environmental aspects and potential impacts associated with a product by:

12. Life cycle assessment usually implies a qualitative approach while life-cycle analysis implies a quantitative approach.

- compiling an inventory of relevant inputs and outputs of a product system;
- evaluating the potential environmental impacts associated with those inputs and outputs;
- interpreting the results of the inventory analysis and impact assessment phases in relation to the objectives of the study.”

Due to resource requirements few LCA's are exhaustive. Most LCA's usually focus on energy consumption in the extraction of raw materials, transport, manufacture, distribution and final disposal of a product. Additional measures may include emissions to air, land or water resulting from the creation and disposal of the product. Thus, using the LCA approach, a firm will be able to assess the environmental performance of a product by identifying potential reductions in environmental impacts during the production process and improvements in the product design – e.g. reductions in the material-intensity of products and evaluation of environmental performance of the product throughout the life cycle. In addition, by establishing a baseline performance, a LCA can be used to assess alternatives for decision-making and reporting.

The ISO has finalised a series of standards for LCA, focussing on the concepts, the technical framework, general methodological requirements and procedural requirements. However, these standards provide only a framework, without concentrating on methods and data in detail. A new project carried out by SETAC and UNEP is to try and resolve of the outstanding questions. These include: allocation of impacts between co-produced outputs, system boundaries, whether average or marginal impacts should be the norm, the relationship between different impacts, and valuation of impacts. There will also be guidance in how the results of this programme can be used as environmental performance indicators for business.

As noted above, LCA is a resource-intensive tool. Data are expensive to collect, particularly for processes and inputs which are external to the firm (upstream or downstream). However, LCA methodologies are becoming increasingly user-friendly and less time- and cost-intensive. In particular, new electronic databases are facilitating LCA. Nonetheless, in some cases costs remain prohibitive for some firms, especially for small and medium sized companies. Moreover and probably more importantly, LCA is a non-monetary, physical flow-based approach. This restricts the uses to which LCA's can be put within the firm. For this reason, several organisations (e.g. SETAC) engaged in the development of material flow models have recently made recommendations about including economic and social variables in LCA.

Environmental Auditing

While LCA's provide a good indication of the potential environmental impacts of products and production processes, they do not evaluate the damages directly. However, firms need a good understanding of its environmental effects in order to evaluate alternative strategies. For instance, environmental liabilities can not be assessed in the absence of an audit of potential damages. Thus, an environmental audit¹³, is a formal method of inspection used to assess a firm's impact on the environment. An environmental audit often includes a risk assessment, which is a qualitative and quantitative evaluation of the risk posed the human health and/or the environment by the release of specific pollutants.

They may be undertaken at different scales, including production audits (assessing the impact of the production process), site audits (focusing on particular factories), and supply-chain audits (including environmental impacts upstream and downstream). Depending upon the scale, the audit should assess the present and potential environmental impacts associated with the production process by:

13. Environmental audits are sometimes also referred to as pollution prevention audits, waste (minimisation) assessments/audits, eco-efficiency audits or cleaner production assessments/audits.

- identifying where resources are used and environmental impacts occur;
- generating options for the reduction of waste and emissions;
- evaluating these options; and
- indicating where a company can integrate preventative measures throughout its activities.

Carrying out an environmental audit can lead to concrete environmental-commercial benefits through identification of opportunities to reduce of waste generation and pollution emissions, improving the efficiency of material use, and providing environmental information to be used in reports and marketing. In order to facilitate and standardise the implementation of such audit systems in 1993 the European Commission adopted the EMAS (Eco Management Audit System) Regulation. This scheme recommends the voluntary participation by firms and gives them guidelines, with the objective of promoting better environmental performance at the site level. Similarly, at world scale, the International Standardisation Organisation launched the ISO 14000 scheme for the certification of corporate environmental management at the firm level.

Box 4. Eco-efficiency Strategy in Philips

Philips, the Netherlands-based electronics giant, adopted a “Global Action Programme” on the environment in 1994. Manufacturing targets included ISO 14001 accreditation for 300 sites by 2001, and 25% energy efficiency improvement. By 2000, Philips aimed to reduce packaging by 15% and to introduce eco-design principles in its products. By 1999 only 80 sites were accredited for ISO 14001 and energy savings amount to only 16%, despite calculated payback periods of 1-3 years for many conservation measures. There are success stories in the firm, but insufficient monitoring data, on packaging reduction, and few products have incorporated eco-design principles.

Motivated by investor interest, poor results in company rankings on environmental reporting, and strong interest at board level, Philips adopted a new programme in 1998. The programme emphasises the environment as a central feature in product branding. Philips has found that its greener products have commanded higher market share and a price premium while reducing material costs. Environmental performance targets in the new marketing drive will be developed at the division level. Globally, Philips aims to achieve and go beyond the targets adopted in 1994 and has adopted additional goals of 35% waste reduction and 25% reduction in water use by 2002, along with large reductions in the use of hazardous substances

Environmental Accounting

Environmental accounting is a relatively new environmental management tool, and is really just an extension of the increased use of “true”, “full” or “life-cycle” accounting. Full-cost accounting means the allocation of all direct and indirect costs and benefits to a product, and not just the direct tangible financial costs. Thus, whereas traditional financial accounting systems focus only on clearly identifiable costs to the firm by defining environmental costs and benefits narrowly, environmental accounting would seek to evaluate some of the less readily quantifiable (private) costs and benefits. Uncovering and recognising hidden environmental costs and benefits associated with a product, process or even the firm is important for decision-makers in firms.

In this respect one can differentiate between different types of environmental costs. These can be distinguished as follows:

- *Costs of using raw materials, utilities, capital goods, and suppliers.* These costs are usually not considered as environmental costs and would be accounted for in standard accounting procedures.

- *Potentially hidden costs.* These would include environment-related costs for research and development, reporting, environmental insurance, medical surveillance, site preparation, environmental training of the staff, pollution control, etc.... Such costs are often not considered explicitly by financial accounting systems because they are assigned to other accounting items or to the administrative overhead of the company.
- *Liability and risk costs.* These are costs of remedying and compensating for future accidental releases of contaminants into the environment, fines and penalties for future costs due to unexpected consequences of permitted or intentional releases. Due to uncertainty they are often not treated adequately.
- *Corporate image costs.* This would include expenditures related to annual environmental reports, voluntary environmental activities, and loss of reputation for damaging activities.

Thus, the use of an environmental accounting system should help managers target cost reduction. It will also for improved communication within the firm (e.g. between financial and environmental health and safety divisions). And finally, it should assist in the evaluation of the performance of different divisions, product lines and personnel.

Perhaps more importantly, in the longer-term environmental accounting should help a firm assess alternative market strategies by helping to evaluate the benefit side. (See Boyd 1998 for a discussion.) For instance, environmental accounting should allow firms to evaluate the potential to win market share through environmentally-motivated product differentiation or by tapping new markets through product development. With traditional accounting procedures firms may underestimate the rate of return by underestimating the “value” which consumers attach to the environment. (See ELI 1999). They will, therefore, undervalue the future stream of commercial benefits. Given the rate of change in environmental preferences this likelihood would appear to be considerable in the area of environmental investments. The more systematic use of environmental accounting should help to alleviate this problem. (See Epstein and Young 1998).

3.3.2 *Communication Instruments*

While the environmental tools discussed above are designed to generate information and provide a framework within which they can be analysed, the information generated can be used by the company for different purposes. In this sub-section we will review three such uses: environmental reporting, environmentally-motivated advertising, and environmental benchmarking.

Corporate Environmental Reporting

Environmental information can be communicated to a wide audience by a corporate environmental report. These reports can be either stand-alone documents or annexes to annual reports. They vary significantly in comprehensiveness. In general, however, they are increasing in quality through time. (See Siniscalco et al 2000 for some evidence on quality issues.)

The purpose of a CER is to show the environmental performance of the company to staff and interested stakeholders. Preparing a CER should generate the following benefits amongst different groups of stakeholders:

- increase employee awareness of the environmental performance of the firm and thus motivate them and allow them to participate in goal-setting;
- help the firm to expand market share or capture entirely new markets;
- help to raise finance; and
- improve the corporate image of the firm with local communities and others.

Despite these advantages corporate environmental reporting is not used extensively. Siniscalco et al's (2000) survey only included 150 firms with stand-alone reports in 1998, although the number had grown from less than 50 just three years previously. Also the existing reports are not always as instructive as might be hoped. This might be due in part to the fear that the results of their audits could be used against them (Welford 1999). Thus, it is important to bear in mind that corporate environmental reporting, as a voluntary undertaking, will generally tend to put firms in a favourable light, usually by disclosing information selectively. (See Welford 1999.)

In order to overcome these barriers work is being undertaken to design uniform guidelines for Corporate Environmental Reports, and research is being carried out by a number of bodies in this vein. There have been various initiatives to develop a standardised template. In 1997 the Coalition for Environmentally Responsible Economies (CERES) established the Global Reporting Initiative (GRI) that aims to set up a uniform standard. Members of GRI include the various stakeholders like reporting companies, users and experts. The first exposure guideline was published in 1999 and identified several main topics for reporting; the second one is going to be published. It is expected to finalise its work in 2002/2003.

Environmental Benchmarking

Corporate Environmental Benchmarking involves the comparison, ranking or rating of different business processes, units or companies against particular standards. The aim is to identify ways of improving the performance of operations, systems, and processes. Given the heterogeneity of firm characteristics and environmental impacts this can be a complicated procedure. (See the discussion on indicators above.) However, it does provide firms with a means whereby they can assess their relative performance in environmental terms.

A study by the Dutch National Institute of Public Health and Environmental Protection found up to a ten-fold difference in emissions for similar processes in several industries. (See EC DGE 2000.) Both the worst and the best performers were frequently unaware of how they compared relative to others in the industry. Further investigation showed that the reasons were often trivial, for example minor differences in process controls that could be readily changed to produce substantial improvements. By highlighting differences in performance, benchmarking allows firms to identify areas in which they are leading as well as lagging. Used internally it can also help a firm compare performance across divisions and product lines.

However, there are a number of barriers to using the benchmarking tool. These include lack of information on its potential benefits; lack of knowledge about benchmarking techniques and indicators; firms reluctance to disclose internal information to others. A European Environmental Benchmarking Network (EEBN) has now been established to overcome these barriers. Its specific objectives are to collate and learn from existing environmental benchmarking initiatives; to establish a dialogue about benchmarking between industry and its stakeholders; to disseminate information about benchmarking (e.g. through a website, newsletters, conferences and publications); and to develop pilot benchmarking projects.

Marketing/Advertising

Marketing on environmental grounds is becoming increasingly common. In general it is a means whereby the firm can differentiate its outputs in such a way as to allow it to tap niche markets and drive down the price elasticity of demand for its products. In this way some of the expenditures devoted toward improving environmental performance can be recovered. Thus, marketing on the basis of environmental characteristics is a means by which improved environmental performance can lead to commercial benefits, even in cases where costs have risen.

Such marketing can be done at the level of the product (“environmental differentiation”) or at the level of the firm (“environmental branding”). They can also be done co-operatively, such as through the use of private eco-labelling schemes. Such efforts are more likely to be successful for firms which sell primarily to final consumers and where there is a close link between private interests and external environmental benefits. Fuel efficiency in private motor vehicles is one such example.

Even to a greater extent than corporate environmental reporting such a tool suffers from credibility problems since the claims made can not be substantiated directly by the consumer. (See Karl and Orwatt 2000.) This is particularly important for claims made on the basis of the environmental characteristics of production processes, rather than of the products themselves. Protection against dubious claims is provided in most OECD countries through general regulation of the advertising sector. However, a number of countries (e.g. the United States) have introduced specific legislation to deal with claims of environmental superiority. (See Karl and Orwatt 2000).

3.3.3 *Human Resource Tools*

As noted above, one of the biggest sources of “organisational” failure arise from principal-agent problems – i.e. the difficulty of aligning the incentives of employees with the incentives of owners and senior managers. (See Gabel and Sinclair-Desgagné 2000.) This is an endemic problem in firms, but can be particularly important for environmental concerns since “incentive-compatible” systems are particularly difficult to implement in areas where costs and benefits are difficult to quantify. Three “tools” will be explored: employee compensation, performance evaluation and recruitment, and training schemes.

Compensation and Awards

Since environmental costs and (more clearly) benefits are difficult to quantify it can be difficult to provide incentives for employees to identify projects with positive environmental repercussions and/or identify potential environmental risks. This is becoming increasingly important at the senior management level as the proportion of bonuses relative to fixed salaries in total compensation packages rises. Since these bonuses are tied to financial performance (often defined narrowly), managers with environmental responsibilities may not be given sufficient incentive to identify projects where the returns are more uncertain, longer-term, or intangible. However, according to Siniscalco et al. (2000), over 70% of firms in their survey of 476 firms had environment-related compensation or award schemes in place.

In such cases it is generally argued that while compensation packages for managers with financial responsibilities should be weighted toward “strong” incentives, for managers with environmental responsibilities, the incentives should be relatively weaker with a greater proportion made up by a fixed salary. (See Gabel and Sinclair-Desgagné 2000.) However, in some cases the monitoring costs required to devise compensation schemes which reward employees for their efforts to improve the environmental performance of the firm will be excessive. In this case, it is important that those with environmental responsibilities not hold other responsibilities as well since it will make it more difficult to ensure that efforts are being allocated efficiently across the firm.¹⁴

More generally, firms have adopted a wide range of incentive schemes to motivate personnel throughout the firm to identify positive environment-related commercial opportunities and reduce negative environmental risks. Focussing on personnel at the shop-floor level an incentive scheme might be useful to

14. This is, however, controversial since much of the management literature advocates more decentralised responsibility for environmental concerns.

exploit cost savings associated with the production process. In this case savings are often a result of more efficient workplace methods, rather than technological innovations. Some firms provide incentives on the individual level. Staff members that identify environmental-commercial opportunities will get either a fixed bonus or a proportion of the savings. Dow has used such a scheme in its “Waste Reduction Always Pays” programme, which generated \$10 million in savings. (See Corbett and van Wassnhove 2000.). Other firms focus on the group level by initiating contests between different division of the firm in order to award prizes for the division that uses less resources compared with the previous year.

Performance Evaluation and Recruitment

More generally, firms can also integrate environmental concerns into their staff performance evaluations and promotions. This policy is particularly attractive for long-term agency relationships where the cost of generating information is very high. Rather than rewarding staff frequently through bonuses (thus increasing the cost of collecting relevant information), employees who play an important role in improving the environmental performance of the firm can be rewarded through less frequent promotions in the course of usual performance evaluations.

This policy will, however, only affect employees within the firm. An alternative (or complementary) strategy is to make environmental issues (values and skills) an important component of the evaluation of external applicants. On the one hand, this allows firms to ensure that in time the values of the personnel will match the firm’s “corporate culture” with respect to environmental matters. On the other hand, it also increases the capacity of employees to identify and act upon business opportunities with positive environmental consequences.

Employee Training

A third category of human resource-related environmental management tool relates to “environmental training”. This is a means whereby firms can increase their existing workforce’s sensitivity to environmental concerns, as well as their capacity to identify business opportunities with positive environmental consequences. Firms have introduced different types of training programs, including:

- education for all employees in general awareness of environmental concerns relevant for the firm;
- education and training toward modifying work practices, processes and materials to reduce the environmental impact of industrial processes on local communities;
- professional education for engineers and others seeking expertise and careers in environmental fields; and
- education and training of workers in hazardous waste clean-up, emergency response to spills, accidental releases and other accidents.

Such programmes are becomingly increasingly widespread. For instance, in Dasgupta et al.’s (1997) study of Mexican manufacturing firms 32.6% of firms had programmes for “environmental training for non-environmental personnel” in place. However, since environmental awareness and sensitivity of employees may often be in excess of management’s, such “training” should also be used to help managers identify those values which are important to employees, and thus need to be reflected in the firm if they are to ensure that staff are motivated.

3.4 *Barriers to the Implementation of Environmental Management Tools*

It is only a small (but growing) minority of firms which use them in a concerted manner. There are at least four reasons why business is reluctant to use such tools:

- **Lack of Information** - Despite efforts to raise awareness among decision-makers, many firms (particularly small- and medium-sized enterprises) are not aware of the potential uses of various environmental management tools. In particular, it is difficult to obtain appropriate information, which considers the firm's business field, the level of technology employed, the firm's structure and size, and the previous knowledge of the decision-makers.
- **Moral Hazard** – For information-related tools, firms may be reluctant to reveal data generated out of a fear that it may result in pressure from various stakeholders. For instance, consumer groups and environmental NGOs could ask for further improvements in environmental performance. Perhaps more significantly, firms may fear that public policy makers could use the data against them in the future. (See Pfaff and Sanchirico 1999 and Welford 1999.)
- **Cost and Complexity of the Tools** - Environmental management tools can be difficult and costly to introduce. Although environmental tools are increasingly becoming more user-friendly and less time- and cost-intensive, this remains a concern. For instance, a survey of German firms found that it took an average of 14 months and one-person year of personnel resources for the implementation of an EMAS. (See German Federal Environment Agency 2000). For instance, environmental accounting demands a high level of co-operation within the different departments of the firm. (See Andrews et al. 2001 for a discussion.)
- **Intangibility and Uncertainty of Results** – While the application of environmental management tools tends to generate environmental benefits with positive commercial consequences, there is considerable uncertainty. For instance, 75% of German companies found it difficult to quote an exact figure for the costs saved. (See German Federal Environment Agency 2000.) Moreover, the benefits are often difficult to quantify. As such, it is often in the hands of management to determine the speed and intensity of the process. In this context, it is important that performance meets expectations and continues to meet corporate policy requirement (Welford 1999).

As one possible means of addressing questions of uncertainty, complexity, risk and cost, firms have reverted to various forms of “performance contracting”. This strategy grew out of the oil crises as energy-intensive firms sought strategies to exploit energy saving opportunities. With many firms lacking the skills to identify and act upon some opportunities, the role of energy management consultants grew to meet the needs of energy-using firms through performance contracts. In recent years, performance contractors have recognised changing market needs and have started to address environmental-commercial opportunities more generally. However, while the field has grown, due to the importance of energy costs the contractor still usually concentrates on the systems used for air pressure, cooling steam, and hot water. Other areas which may also have big saving potentials include the consumption of water, material inputs and waste generation. In some cases the firm may also look at processes which generate emissions to air and water.

By outsourcing parts of their business, the contracting firms hope to reduce risks which are not central to the firm's core business. The strategy may also help to increase the knowledge of the operating staff. Thus, the firm expects to run their business more effectively and productively by contracting a specialist firm to help firms to exploit environmental-commercial opportunities. In effect, the customer outsources some aspects of the environmental management of the firm to the contractor for a certain period

of time. Within the contract period the contractor seeks to identify cost saving opportunities and investment needs. This strategy is similar to developments in other areas - information technology, human resources and customer relations – where particular aspects of the firm’s operations have been outsourced in order to concentrate on the firm’s essential business operations.

The contractor undertakes all relevant investments, and therefore accepts the commercial risk. In order to cover the investments, the contractor usually keeps 80% – 90% of the cost saving during the contract period, which is usually between 2 and 8 years. The firm gets a minor part of the cost saving (10%-20%) throughout the duration of the contract, as well as the total cost saving after the end of the contract period. In some cases there is a contract penalty, in the event that agreed minimum cost savings are not achieved. However, in order to be effective, performance contracting in this area needs to meet certain conditions:

- Generally, contracting is only worthwhile once in the lifetime of a building and the production process. Once these objectives are optimised the benefit for a second round of optimisation will not yield sufficient cost savings. However, there may be exceptions in cases where the regulatory environment or resource prices change in a significant way.
- In a related vein, performance contracting is highly dependent on energy prices due to the synergies between energy use and environmental objectives generally. Thus it is often only in cases of high-energy prices where the benefit will be big enough to generate an attractive return, particularly since the amortisation period is usually less than eight years.

In summary, organisational structures can be “barriers” to the identification of environmental-commercial opportunities. Business uses different environmental management “tools” in order to try and overcome some of these barriers. Nevertheless it is only a small number of firms which use such tools since there are factors which hinder their wider use. As a response, some specialist firms have started to offer various types of environment-related performance contracting services.

4. Evidence of Environmental Performance at the Level of the Firm

There is surprisingly little empirical literature on the links between firm characteristics, management systems, environmental performance and commercial success.¹⁵ This may sound surprising since the business literature is full of “success stories” in which firms have identified commercial opportunities which yield important environmental benefits. Indeed, entire web-sites are devoted to the enumeration and description of examples where firms have managed to improve their environmental performance and profit margins at the same time. (See <http://www.wbcsd.org> and <http://www.wri.org>.)

However, while valuable at one level, such evidence provides little information that can be used at the level of policy design. Even with the best “quality controls” in place, firms have a clear interest in presenting such information in a partial (and perhaps even biased) manner. More importantly, as with any field, one learns as much from those who do not undertake particular actions as from those who do. In this vein, it is important to review evidence based upon broad samples of firms which are not self-selected.

15. In the initial stages of the project a series of sector-level case studies were prepared. However, as the project developed it became clear that studies which were more closely focussed at the level of the firm were more relevant to the project. As such this section relies upon secondary literature. The main conclusions of the sector-level studies are reproduced in Annex 1.

In this section some of the more formal empirical evidence will be reviewed. This will include a review of the evidence on the relationship between firm characteristics and environmental performance, a review of surveys of self-assessments of the relative importance of different “drivers” which are encouraging improved environmental performance, and a review of the studies which have looked at the links between environmental management and performance. In addition, the more formal empirical evidence on the relationship between financial and commercial performance will be reviewed.

4.1 *Firm Characteristics and Environmental Performance*

Due to the importance of exogenous firm characteristics (size, fuel type, diversification) there can be as much variation in environmental performance within a sector as there is for “similar” plants in different sectors. (See Streetweiser 1994 for some empirical evidence from the United States.) Identifying the links between such characteristics and environmental performance is key. Firstly, this will help public authorities target scarce resources toward areas where it can be of the greatest use. Secondly, it will help public authorities enforce regulations more efficiently. Thirdly, it may help policymakers design policies differently for different “segments” of the industry.

The empirical literature which does exist hypothesises a number of relationships between various “exogenous” firm characteristics and environmental performance. (See Annex 2 for a fuller discussion.) A number of issues are thought to be particularly important:

- Firm size - presumed positive due to visibility (and thus probability of enforcement and strength of community pressures), as well as economies of scale in environmental improvements
- Capital stock turnover – presumed positive due to “cleaner” nature of many newer technologies relative to older technologies
- Exposure to international markets – presumed positive due to need to meet standards of most stringent market and benefits of standardisation
- Geographical origins of capital – ambiguous depending upon relative stringency of domestic regulations relative to other countries
- Source of equity – presumed positive for firms with stock exchange listings due to environmental demands of equity markets
- Capital availability – positive for firms with internal sources of funds due to capital costs of investments in environmental improvements¹⁶
- Public authorities vs. private firms – negative for public authorities due to lower probability of enforcement and existence of soft budget constraints which discourages material efficiency¹⁷
- Diversity of product lines – negative due to diseconomies of scope in investment in environmental improvements
- Proximity to final consumers – positive due to importance of environmental demands of final consumers

As noted, the empirical evidence for these relationships is surprisingly thin on the ground, with very few studies looking systematically at the relationship between firm characteristics and environmental performance. A number of studies do so in a descriptive manner (e.g. UNCTAD 1993), reporting on the degree of correlation between some of these factors and environmental performance. However, these results are not of particular use since there is such a high degree of correlation between the various

16. This assumes that the opportunity cost of internal funds is less than market capital costs.

17. Although the latter effect is ambiguous since this may allow for investment in costly investments in environmental improvements.

explanatory factors analysed. For instance, large firms tend to have greater access to capital, tend to be more exposed to international markets and are more likely to have public shareholdings. Thus a high degree of correlation between environmental performance and any of these factors may say very little about the actual nature of the relationship in question. The “true” relationship (as revealed in multivariate analysis) may be much stronger or weaker, and may even change direction.

Moreover, it is very difficult to define an appropriate variable for environmental performance. For instance, in the studies which are reviewed in Annex 2, the following indicators are used: visible evidence of abatement efforts, reported emission rates, self-assessed environmental performance, and involvement in a voluntary environmental programme. All of these “proxies” have some methodological problems. Nonetheless, the evidence is revealing and of interest. (Table 4 provides a summary of the general results. See the Annex 2 for a fuller discussion.)

Table 4: Firm Characteristics and Environmental Performance

Characteristic	Hypothesised Relationship	Evidence
Firm Size	Larger -> improvement	Generally supported
Capital Vintage	Newer -> improvement	Not supported
Trade Ratio	Highly traded -> improvement	Weakly supported
Investment Source	Foreign -> improvement	Not supported
Source of Equity	Public shareholdings -> improvement	Generally supported
Capital Availability	Internal -> improvement	Generally supported
Institutional Characteristics	Private firm -> improvement	Generally supported
Proximity to Final Consumers	Closer -> improvement	Weakly supported
Diversity of Product Lines	Specialisation -> improvement	Generally supported

4.2 Self-Reported Determinants of the Environmental Performance of Firms

While it is clear that some structural firm characteristics affect environmental performance, such factors are not the causal determinants of improved environmental performance. In this section some of these “drivers” will be explored, drawing once again upon the empirical evidence. A number of studies have tried to evaluate the relative importance of different factors in bringing about changes in a firm’s environmental policies and performance through surveys of firm managers. Table 5 summarises the findings from eight surveys. However, it is important to note that responses will vary significantly depending upon the precise form of the question posed and the classifications used as potential responses. Moreover, managers themselves may not recognise the relative importance of different factors, particularly since some pressures can manifest themselves through very indirect channels. Nonetheless some general insights can be obtained from a comparison of survey results.

What do the surveys show? Firstly, regulations matter. In all but two studies they are ranked highest. One reason for the outliers may be that in one study where they are not ranked highest the firms surveyed were not chosen randomly, but were instead “suggested” by the state environmental protection agencies. In the other case, the question posed related to “product development” where regulations are less important and where customer preferences are much more closely bound up with environmental attributes. However, it must also be recognised that firms may have a strategic interest in overstating the importance of regulatory requirements. Liability also proves to be a strong influence in the two studies in which it is included. The same holds for industry codes, although in this case only one study included it as a potential response. (Arguably, the behaviour of other firms – important in the UNCTAD study - is closely related.)

Table 5: Rankings of Drivers of Environmental Performance

Kestemont and Ytterhus (1997) – Europe	Deni Greene (1998) – Australia	Henriques and Sadorsky (1996) – Canada	Monash (1998) – Australia	Morrison (1991) – United States	UNCTAD (1993) – European, Japanese and American TNCs	Lefebvre et al. (1995) – Quebec	Garrod and Chadwick (1996) – United Kingdom
Influence of Factors when Considering/ Undertaking an Env'tal Initiative	Reasons for Making Env'tal Improvement	Importance of Sources of Pressure to Consider Environmental Issues	External Factors Strongly Influencing Corporate Environmental Strategy	Factors Reflected in Env'tal Policy Decisions	Factors Influencing Change in Env'tal Policies and Programmes	Motives for Integrating Env'tal Concerns into Product Development	Source of Greatest Env'tal Influence
Env'tal Regulations	Money Savings	Env'tal Regulations	Env'tal Regulations	Regulatory Requirements	Home Legislation	Customer Requirements	Regulatory Authorities
Management Motivation	Management Motivation	Cost of Controls	Compliance with Industry Codes	Social Responsibility	Own Legal Actions	Domestic Regulations	Customers
Customers	Env'tal Regulations	Employees	Corporate Citizenship	Liability Pressure	Env'tal Accidents – Other Firms	Market Opportunities	Others (trade unions, banks, suppliers, etc....)
International Regulations	Occupational H&S	Efficiency Gains	Productivity Improvement	Community Pressure	Host Legislation	Competing Products	
Owners/ Shareholders	Community Pressure	Customers	Env'tal Reporting Requirements	Shareholder Pressure	Legal Actions – Other Firms	Foreign Regulations	
Employees	Other	N'hood/ Community	Customer Requirements		Own Env'tal Accidents	Suppliers	
Voluntary Agreements		Shareholders	Voluntary Gov't Initiatives		Consumer Events	Ecological Groups	
Local Community		Env'tal Organisations	Finance and Lending Criteria		Worker Events		
Env'tal Organisations		Other	Markets for Green Products				

With respect to the scope of this study, commercial and financial considerations figure relatively prominently. It is revealing that supply-side commercial concerns (e.g. money savings, productivity improvements, efficiency gains, etc....) are reported to be an important factor in those studies in which they are listed as a potential response. In addition, managerial motivations are cited prominently for those surveys which included them. However, consumer pressure appears to be surprisingly weak, except in the case mentioned above related to product development. While it ranks second in one other study, it is well behind regulatory pressure. In those surveys which include financial pressures (e.g. lending criteria, shareholder pressure, etc....), it is also quite weak.

However, a number of econometric studies have found that environmental performance does have significant and positive effects on financial performance. Thus, it may be that firms themselves do not recognise the importance of the influence. Given these results (and the focus of the study), the next sub-section reviews more formal statistical evidence on the links between environmental and commercial and financial success.

4.3 Environmental Management and Environmental Performance

Do environmental management systems and tools actually result in improved environmental performance? There is much anecdotal evidence in this area in which individual firms have reported the benefits of introducing particular environmental strategies. Thus, it is widely reported that environmental auditing, environmental management systems, and other tools have played a decisive role in bringing about improved environmental performance. Unfortunately, there is very little formal empirical evidence in this area. This is particularly important since many studies (and indeed policies) use management systems as "proxies" for performance. A small number of studies do provide some evidence.

In a study of Mexican manufacturing firms Dasgupta et al (1997) undertook an analysis in which they evaluated the importance of the presence of various environmental management and policy indicators

on reported environmental performance. They found that three factors had significant and positive effects: the number of steps completed in ISO 14000 EMS, a dummy variable for whether or not environmental training had been given to non-environmental workers, and a dummy variable for whether or not environmental managers were assigned to other work in the firm. The latter two results reveal the importance of “mainstreaming”, an issue discussed below.

In their survey of firms Siniscalco et al (2000) found that between the years 1994-1997 reported SO_x and NO_x pollution rates fell more for firms with environmental management tools (compensation schemes, audits and award schemes) than those without such schemes. In multivariate analysis they found that the quality of the information provided in environmental reports had a negative (i.e. beneficial) and significant effect on pollution rates. Audits, compensation schemes and award programmes also had a beneficial effect, but it arose indirectly through their effect on financial performance.

In addition, in the statistical analysis of the EBEB survey (see Annex 3) it was found that the presence of a certified EMS (EMAS or ISO) had a positive effect on the number of “environmental initiatives” undertaken by a firm. (See also Andrews et al. 1999.) Indeed, and rather surprisingly, the coefficient for certification was more significant than any of the other variables, including national and sectoral dummy variables.

Conversely, Levy’s (1995) analysis of the UNCTAD Benchmark Survey does not find supporting evidence. American-based firms which produced annual environmental reports, which had company-wide environmental policies in place, and which had standardised procedures for environmental practices were no more likely to have reduced their emissions of toxics than other firms. Other studies have, however, found some evidence that reporting does result in reduced emissions. (See, for instance, Konar and Cohen 1997). However, most of these studies are based upon public environmental registries, where credibility issues are less important.

4.4 *Commercial and Financial Benefits of Improved Environmental Performance*

Does improved environmental performance yield commercial benefits? There is no shortage of firms that argue that this is indeed the case. For instance, to take one particularly well-known example 3M cited savings of \$500 million between 1975-1990 with a 50% reduction in total emissions. (Although at least some of these savings are attributable to the regulatory framework (compliance and liability costs) and thus are not really “win wins” in the sense usually used.) (See Hart and Ahuja 1996.) Looking at this issue from the perspective of stock market valuations, a number of “environmental” funds and indices (e.g. Innovest, Dow Jones Sustainability Group) have outperformed the market average. (See World Resource Institute 2000b for a discussion.)

What does the more formal empirical evidence say? Due to the much greater degree of accessibility and transparency which exists in the United States with respect to environmental data most of the evidence in this area is American, usually based upon the Toxic Releases Inventory. In most cases various measures of financial return are used as the dependent variable since with efficient capital markets these should be good guides to the discounted value of future costs and revenues. However, sales growth and other variables are also occasionally used as dependent variables.

Along with other pertinent explanatory variables, Hart and Ahuja (1996) use data on toxic emission reductions reported in the Investor Responsibility Research Center’s database to explain three indicators of financial/commercial performance (returns on sales, returns on assets and returns on equity). They find that with a short lag (one or two years) there is a positive relationship between improved environmental performance and financial/commercial performance. Russo and Fouts (1997) examined the “return on assets” for 243 American firms, and found that “environmental ratings” (based upon compliance

records, abatement expenditures, support for environmental NGO's, and other factors) had a positive and significant influence. Levy (1995) conducted a study for Japanese, European and North American TNC's based in the United States. However, he finds no evidence of a positive relationship between reductions in toxic emissions and changes in the returns on sales or assets, or in the growth rate of sales.

Konar and Cohen (1997) used a much larger dataset (321 firms) to look at the effects of two indicators of environmental performance (toxic emissions per dollar of revenue and number of environmental lawsuits pending) on "intangible asset values".¹⁸ The latter is an indicator of the discounted value of the firm's future earning power arising from specialised assets such as reputation, trust, patents, etc... Thus, if reduced emissions or lawsuits is thought to have effects on future environment-related costs (e.g. liabilities) or revenues (e.g. due to reputation effects) intangible asset values should be higher than normal. Indeed, they find that both indicators of environmental performance have significant effects on the market valuation of intangible assets. Simulations indicate that the average loss associated with TRI emissions is equal to 8.4% of the replacement value of the average firms assets. Conversely, the effect of pending lawsuits is not large in magnitude.

Using the same database, Khanna and Damon (1999) found that emissions of those pollutants included in the United States' 33/50 programme had a negative effect on returns on investment, but a positive effect on the ratio of the valuation of intangible assets relative to sales. Since the former is a indicator of short-run performance and the latter of long-run performance, these results are significant and revealing. Using quite a different methodology ("event study methodology"), Hamilton (1995) looked at the effects of the release of TRI information on US stock market prices in the days immediately following publication. He found that there was a significant and negative effect on stockmarket values for those firms which reported emissions. However, rather surprisingly he did not find any relationship between the level of emissions and the value of the change in returns.

There have been three Canadian studies. Using event study methodology methodology, Lanoie et al (1998) do not find that in British Columbia "environmental news" (publication of Ministry of Environment lists of non-compliers and heavy emitters) affects equity prices in a significant manner. However, the sample size was very small. Laplante and Lanoie (1994) also used event methodology to look at the effects of four types of "news" (lawsuits, settlements, environmental incidents and investments in pollution abatement equipment) in Canada between 1982 and 1991. While lawsuits and incidents have no effect, settlements and investments have significant and negative effects. A third Canadian study (Cormier et al. 1993) looked at the effect of water pollution discharges relative to regulatory standards on the valuation of intangible assets. They found relatively weak evidence that higher relative discharge rates had a negative and significant effect on the valuation of intangible assets.

Overall, the results of such studies appear to reveal that there is a significant and positive relationship between environmental performance and commercial and financial results. This result does not hold up particularly well for short-run effects on stock market valuations (e.g. using event study methodology), but for most other cases (annual growth in sales, annual return on assets, valuation of intangible assets, etc...) there is good support for the hypothesis. However, the quality of the data and of the estimation models used is important. For instance, there is significant potential for simultaneous determination (e.g. improved commercial performance allowing for improved environmental performance and *vice versa*), suggesting that the results need to be interpreted with care.

18. This is measured indirectly using "Tobin's q", which is the ratio of the market value of the firm (equity, debt and preferred stock) over the replacement value of tangible assets (plant, equipment, inventories, and science and technology assets).

5. Analysis of Environmental Management and Performance of European Firms

The previous sub-section has reviewed the empirical literature related to firm characteristics, management systems, environmental performance, and commercial success. In order to cast further light on these issues, the Secretariat has undertaken an empirical study drawing upon a survey of over 2,000 European manufacturing firms conducted by a consortium of research institutes and university departments. The survey (the European Business Environmental Barometer)¹⁹ was undertaken in 1997, and allows us to explore two questions: what are the characteristics of firms which are most likely to adopt environmental management systems; and, how important are environmental management systems in improving environmental performance.²⁰

5.1 *The European Business Environmental Barometer Survey*

The tool employed in the project is a written questionnaire administered regularly, with the aim to provide not only a snapshot of the variables (and relationships) of interest at a single point in time, but also to provide a longer-term view of developments. However, this report only analyses the results from a particular period (1997). The survey covered firms in thirteen European economies: The participating countries were: Austria, Belgium, Finland, France, Germany, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden and Switzerland. However, due to differences in the administration of the survey, respondents from Ireland and Finland are not included in the data analysis. Only manufacturing firms with more than 50 employees were targeted, with respondents classified into the following NACE sub-sectors:

- food products, beverage and tobacco (FOODPROD)
- textiles and textile products (TEXTILES)
- leather and leather products (LEATHER)
- wood and wood products (WOODPROD)
- pulp, paper and paper products, publishing and printing (PULP&PPR)
- coke, refined petroleum products and nuclear fuel (FUELPROD)
- chemicals, chemical products and manmade fibres (CHEMPROD)
- rubber and plastic products (RBBRPLST)
- other nonmetallic mineral products (OTHRMNRL)
- basic metals and fabricated metal products (MTALPROD)
- machinery and equipment (MACHEQPN)
- electrical and optical equipment (ELECPROD)
- transport equipment (TRNSEQPN)

The survey was carried out by post, targeting designated respondents within each firm (usually CEO's). Each member institute of the EBEB was responsible for the administration of the questionnaire in its country and the questionnaire was administered in the appropriate language. The first step in obtaining the sample was to define the population from which the sample of companies would be extracted. It was decided that only firms with at least 50 employees from manufacturing sectors would be included in the population. The second step was to select the individual companies to be contacted. As the business

19 The participating institutes were: University of Innsbrück (Austria), Université Catholique de Louvain (Belgium), Helsinki School of Economics (Finland), Ecole des Mines de Paris (France), Westfälische Wilhelms-Universität Münster (Germany), The Environment Initiative (Ireland), Fondazione Eni Enrico Mattei (Italy), Tilburg University (the Netherlands), Norwegian School of Management (Norway), Instituto das Tecnologias Ambientais (Portugal), Universidad Carlos III de Madrid (Spain), Gothenburg Research Institute (Sweden), and University of St. Gallen (Switzerland).

20. The analysis was undertaken jointly with Marie-Paule Kestemont from the Université Catholique de Louvain, and Bjarne Ytterhus from the Norwegian School of Management.

structure is not the same in all countries, the sampling procedure has to respect these differences in order to generate representative samples. Given these constraints on the sampling procedure one has to construct a random sample (proportional or not proportional stratified sample). The numbers of questionnaires posted and the responses received in the different countries are given in Table 6 below.

Table 6. Responses by Country and Firm Size

Country	N	Responses	Response Rate	Responses by Company Size (# of Employees)			
				50-99	100-249	250-499	>499
Austria	850	190	22.4%	11	23	35	65
Belgium	3000	364	12.1%	109	122	67	66
France	1915	191	10.0%	39	39	17	96
Germany	1200	155	12.9%	2	13	19	116
Italy	2000	181	9.1%	41	46	58	29
Netherlands	2165	527	24.3%	161	214	81	67
Norway	1005	313	31.1%	108	108	44	31
Portugal	1536	300	19.5%	94	98	68	40
Spain	1500	113	7.5%	1	13	36	55
Sweden	661	336	50.8%	154	70	69	43
Switzerland	800	250	31.3%	75	97	37	30

Kestemont and Ytterhus (1997) provides a comprehensive overview of some of the main descriptive results of the survey. Salient results include the following:

- Respondents in most countries felt that generation of solid waste and energy consumption were the main environmental problems, followed by waste water;
- The most important “stakeholder” affecting a firm’s environmental performance tended to be national regulators, followed by management and customers;
- Certified environmental management systems were most common in Germany, Austria, Sweden and Switzerland; and,
- Certified environmental management systems were most common in firms in the transport, paper chemicals, and coke/petroleum sectors.

Table 7. Percentage of Firms with Different Environmental Management Measures

Measure	% of Firms
Written Environment Policy	45.1
Environmental Auditing/Reviewing	44.9
Defined Environmental Responsibilities	41.9
Process to Identify Legal Requirements	40.2
Measurable Environmental Objectives	39.5
Program to Achieve Environmental Objectives	39.0
Periodic Revision of Environmental Objectives	34.6
Environmental Information in Annual Report	28.4
Audits of Environmental Program	26.4
Separate Environmental Report	23.5
Environmental Training Program	19.4

Disaggregating by type of environmental management measure, reveals that firms are most likely to have a written environmental policy and undertake environmental auditing/reviewing. (See Table 7.)

5.2 *Empirical Analysis of Drivers, Barriers and Facilitating Factors*

As noted above, Kestemont and Ytterhus (1997) provide an extensive overview of the survey results and these will not be reproduced here. Instead, an effort will be made to examine more formally the links between firm characteristics, environmental management systems, and environmental performance. Two-stage estimation was undertaken. In the first stage the probability of having a certified environmental management system in place (ISO and/or EMAS) was estimated and in the second-stage the determinants of undertaking environmental “actions” was estimated, using the presence of EMS as one of the explanatory variables. In the first stage we use exogenous characteristics and barriers as explanatory variables, and in the second stage we use exogenous characteristics, the instrument of the EMS/ISO variable, and “drivers” (perceived benefits) as explanatory variables. Schematically the model looks like this:

- Stage I: Firm Characteristics + Reported Barriers to Having EMS/ISO => Probability of Having EMS/ISO
- Stage II: Est'd Prob. of Having EMS/ISO + Firm Characteristics + Reported Drivers => Environmental Actions

The model structure is based upon Dasgupta et al. (1997) who used two-stage estimation to avoid the problem of simultaneity between management policies and environmental performance. By using the first-stage estimate of the likelihood of having an environmental management system in place as the “instrument” in the second-stage estimation of environmental performance, it is possible to isolate the distinct effect of the environmental management system on reported environmental performance. All of the variables were obtained directly from the survey. (The questionnaire is reproduced in Annex 3.)

Stage I Model and Results

In the survey approximately 45% of firms declared that they had environmental management systems in place (or under development), while 55% firms reported that this was not the case. Those who reported having EMS tend to be larger, be more likely to be multidivisional, and more likely to have shares quoted publicly on stock markets. (See Table 8.)

Table 8. Characteristics of Firms With/Without EMS

	EMS in Place or Under Establishment	No EMS in Place or Under Establishment
Number of Firms	1252	1570
Employees (number)	1888	586
Multidivisional (%)	82	61
Quoted Shares (%)	31	11

However, such descriptive statistics are of little use to public authorities due to the high degree of correlation which exists between different firm characteristics. As such more formal analysis of the determinants of the probability of having an EMS was undertaken. The binary nature of the dependent

variable necessitates the use of discrete choice analysis.²¹ The explanatory variables (with relevant question numbers in parentheses) are the following:

Firm Characteristics

- Sectoral dummies (Q1)
- Country dummies
- Dummy if firm is multidivisional (Q3MULTI)
- Firm size (Q2#EMPLS)
- Dummy for listing on stock exchange (Q4QUOTE)

Barriers (Q14)

- Lack of Information (Q141INF)
- Lack of Mngmt Support (Q142MGT)
- Lack of Skilled Personnel (Q143PRF)
- Lack of Financial Support (Q144FIN)
- Difficulties to Organise (Q145ORG)
- Too Costly (Q146COST)

It is recognised that a number of the control variables found to be significant in other studies (e.g. capital-intensity, trade ratio, etc...) are not included in the study, thus potentially resulting in missing variable bias. However, through the inclusion of both country dummies and sectoral dummies it is hoped that most of this may be obviated due to the likely important influence of sectoral and national attributes on the variation of the variables.

The full results from the reduced-form model (retaining variables with 5% statistical significance) are presented in Annex 3. 69% of the cases are predicted successfully and the McFadden R-square (a measure of “goodness of fit”) is 0.14. The statistically significant variables are the country dummies (positive for Belgium, Netherlands, and Spain and negative for Norway and Portugal), Fuel Prod (positive), Employees (positive), Multidivision (positive) and Public Shareholdings (positive). The only statistically significant “barrier” is that for cost.

The use of a binary logistic model is particularly attractive because of the ease of interpretation of the coefficients.²² Converting the coefficients into weighted aggregate elasticities gives an indication of percentage probabilities. For instance, from the weighted aggregate elasticity it is revealed that a 100% increase in the number of employees in a firm increases the probability of having an EMS by just 2.5%. Firms in the Netherlands are 10% more likely to have an EMS than firms from other countries (holding all other factors constant). Multidivision firms are 31% more likely to have an EMS (see Table 9).

21: More specifically, a logistic model is applied and the model takes the form:

$$\ln(\Pi_i / (1 - \Pi_i)) = \beta_0 + \beta_i X_i + \varepsilon$$

Where, Π_i is the probability of Y_i equalling one (i.e. the probability of a firm having a certified environmental management system in place) and X_i is a vector of explanatory variables.

22: Assuming that we are interested in evaluating the effect of a change in X on the probability that Y is equal to 1 it can be shown that:

$$\partial \Pi_i / \partial X_i = \beta \Pi_i (1 - \Pi_i)$$

Table 9. Estimated Probabilities of Having an EMS

Variable	Probabilities (W'd Agg Elasticity)
BELGIUM	0.0529
NETHERLA	0.0999
NORWAY	-0.0363
PORTUGAL	-0.0288
SPAIN	0.0191
FUELPROD	0.0074
Q2EMPLS	0.0254
Q3MULTI	0.3125
Q4QUOTE	0.0409
Q148COST	-0.1758
CONSTANT	-0.4268

Stage II Model and Results

In the second stage the relationship between environmental management systems and reported environmental performance is reviewed. The latter is derived from the sum of answers concerning the number of environmental initiatives undertaken by firms in various stages of production. (Question 9.)²³ This variable is not entirely satisfactory since they do not distinguish between those actions which are not undertaken because they are not relevant to the firm's operations and those which are relevant but not undertaken anyway. Moreover, there is no distinction between type or effectiveness of "initiative". Bearing these reservations in mind into account Table 10 reports the average number of "initiatives" undertaken by firms with EMS in place (or under establishment) relative to those without EMS. (The correlations between EMS and environmental initiatives are in the region of 0.3.)

Table 10: Environmental Management Systems and Environmental Initiatives

	Average Number of Actions by Objective (Question 8)	Average Number of Actions by Production Stage
Firms with EMS in Place (or Under Establishment)	3.73	4.13
Firms without EMS in Place (or Under Establishment)	2.87	3.26

However, more formal analysis is required to disentangle the separate effects of EMS on environmental performance. Thus, in stage II, the estimated probability of having a certified ISO/EMAS is used as an "instrument" in the OLS estimation of the number of "environmental actions" undertaken by different firms. As noted above, the dependent variable is not entirely satisfactory. However, it is hoped that the sectoral dummies will capture some of the distinctions between "no's" which are relevant to the firm's activities and those which are not. The independent variables included are:

Firm Characteristics

- Sectoral dummies (Q1)
- Country dummies
- Dummy if firm is multidivisional (Q3MULTI)

23. Responses to Questions 8 and 10 were also estimated, but the results were not materially different.

- Firm size (Q2#EMPLS)
- Dummy for listed on stock exchange (Q4QUOTE)

Environmental Management System

- Estimated probabilities in Stage I used as instrument (EMSINST)

Drivers (Q13)

- Competitiveness (Q131COMP)
- Corporate Image (Q132CIMG)
- Cost Savings (Q133SAVE)
- LT Profits (Q134LPR)
- Market Share (Q135MRKT)
- New Markets (Q136NEW)
- Owner's Satisfaction (Q137OWNS)
- Product Image (Q138PIMG)
- Productivity Increases (Q139PROD)
- Sales (Q1310SAL)
- ST Profits (Q1311SPR)
- Top Mngmt's Satisfaction (Q1312MGT)

The full results of the reduced-form estimation (retaining variables with greater than 5% statistical significance) are presented in Annex 3.²⁴ While the adjusted-R² is only 0.133 this is not uncommon for a cross-sectional study of this type. Table 11 presents the elasticity estimates (at variable means) of the estimation for the best-fitting model.

Table 11: Determinants of Environmental Performance

Variable	Elasticity at Means
Emsinst	0.1666
France	-0.0063
Netherla	-0.0346
Sweden	-0.0259
Textiles	-0.0157
Leather	-0.0031
Chemprod	0.0085
Rbbrplst	-0.007
Elecprod	-0.0113
Macheqpn	-0.0122
Q132cimg	0.3266
Q136new	0.1112
Q137owns	0.2064
Q1311spr	-0.0933
Q1312mgt	0.1644
Q2empls	0.0053

24. Due to the high degree of heteroskedasticity the reported standard errors are based upon the White correction procedure.

For the purposes of this report it is striking that the most statistically significant variable is the instrument for environmental management systems (EMSINST). At the mean the elasticity is 0.16, indicating that those firms with EMS in place have undertaken 16% more “environmental initiatives”, even when the effects of all other significant factors have been extracted. Of the “drivers” the most important positive factors are corporate image (Q132CIMG), owners’ satisfaction (Q137OWNS) and management satisfaction (Q1312MGT). Surprisingly, market share and cost-related factors are either insignificant or (counter-intuitively) have a negative influence. This is consistent with the more informal studies done on “drivers” reported above. However, as with such studies these results are likely to be biased by the fact that managers are unlikely to report that short-term tangible rewards are more important than longer-run factors which reflect well on their own values.

5.3 Conclusions

The analysis of the EBEB survey results confirms the importance of certain factors such as firm size, exposure to capital markets and degree of decentralisation in determining the likelihood of a firm having an environmental management system. Some of the most interesting results can be summarised as follows:

- Once other factors are held constant, the propensity for firms to have EMS’s in place is not systematically related to their location in Northern or Southern Europe, but rather to country-specific factors.
- Financial costs appear to be the main barrier to the implementation (and certification) of and EMS in the firm.
- Large (measured by number of employees) and diversified (multidivision) firms are more likely to introduce an EMS. This may be due to supply-side factors (economies of scale and scope) or due to demand-side factors (visibility).
- Sectoral factors do not seem to be particularly important determinants of the likelihood of having an EMS, except for fuel producers.
- Reliance upon equity markets (rather than loans or self-financing) appears to provide incentives for the introduction of an EMS.
- The most important self-reported “spurs” to undertaking environment-related initiatives are “soft” factors – namely corporate image and the “values” of the firm’s owners.
- Sectoral classifications affect the environmental “performance” of the firm, even if they do not significantly affect the likelihood of having an EMS in place.

Perhaps the most significant and reassuring result of analysis is the fact that EMS’s tend to have a significant and positive influence on (self-assessed) environmental performance. While the dependent variable used to report the latter is clearly problematic, this result is still welcome and has important implications for policy design. In particular, it is becoming clear that policymakers need to balance flexible “external” policy instruments which give the right incentives with “internal” management-oriented policy instruments which are designed to increase the responsiveness of firms to these incentives.

6 Implications for Public Authorities

From the discussion in the previous section it is clear that the policy framework must not only provide the right “external” incentives for the firm, but it also has a role to play in encouraging firms to recognise and act upon on environmental-commercial opportunities in a timely manner. The shift toward “softer” policy measures has been driven in large part by a desire to change decision-making processes within the firm with respect to environmental matters. These issues are explored with reference to a number of public policy case studies offered by selected member country governments, as well as a review of the secondary literature.

6.1 General Policy Conclusions

There are three broad sets of policy recommendations which emerge from the discussion. **Firstly**, and least controversially, regulators need to introduce policies which have the effect of attaching value to the generation and use of environmental information within the firm. This has more to do with the nature of the instrument applied, than the stringency of the regulation *per se*. The concern, therefore is not with the magnitude of the external incentive itself, but rather with the effect that alternative (nominally equivalent) instruments have on the internal decision-making process within the firm.

Arguably, traditional environmental policy has done the opposite – attaching a low price to such information. For instance, technology-based standards give firms no incentive to “uncover” environmental-commercial synergies. Moreover, they may have also had the effect of encouraging firms to have separate environmental health and safety departments which were concerned with compliance and with only weak links to the rest of the firm. (USEPA 1998 and Shelton and Shopley 1997)

In one sense this is another argument in favour of market-based instruments – along with their benefits in terms of an efficient allocation of environmental effort across firms, and dynamic technological benefits. However, it is important to note that other instruments will also generate such effects. Indeed, any measure which gives firms flexibility in how it meets its environmental targets will do so. Thus, a performance-based standard will do so as well. (See Table 12 for a comparison of the usual efficiency effects of three common instruments.)²⁵ This aspect of environmental policy design (its effects on the allocation of resources *within* a firm) has been largely ignored.

The effect that regulations have on decision-making procedures may, however, be the most important of the three criteria by which the efficiency of an instrument can be evaluated. One example emerges from the US Acid Rain programme. While responsibility for abatement strategies had previously rested largely with environmental health and safety departments, in many cases this was transferred to financial vice presidents and other senior management figures once the tradable permit programme was introduced since the permit holdings were now financial assets and since the implications of the strategy adopted now extended well beyond mere compliance.²⁶

Table 12: The incentive effects of alternative policy instruments

	Improved Resource Allocation Within Firms	Improved Resource Allocation Across Firms	Improved Dynamic Technological Effects
Technology-Based Standard	Negative	Negative	Negative
Performance-Based Standard	Positive	Negative	Somewhat Positive
Market-Based Instrument	Positive	Positive	Positive

Secondly, information-based tools have an important role to play in helping firms to realise commercial-environmental opportunities. For instance, many mandatory emission inventory schemes (e.g

25. Note, however, that these effects can be attenuated through adjustments in policy design and implementation. For instance, while a uniform performance-based standard may not be efficient in terms of the allocation of abatement efforts across firms, if it is adjusted to reflect abatement costs then it will do so. However, this will involve significant administration costs.

26. Personal communication, Dallas Burtraw, Senior Research Fellow, Resources for the Future, Washington D.C.

the TRI in the United States and the NRPI in Canada) can help firms to differentiate themselves on environmental grounds in a credible manner. (See Coglianesi and Nash 2001 for a discussion.) However, this is dependent upon the public availability of the data generated. In addition, some “voluntary” environmental programmes (e.g. the American EPA’s 33/50) advertise membership in the programme on behalf of firms. Alternatively, public recognition for firms with environmental management systems can be considered. This may allow firms to differentiate their performance in a more credible manner. (See Coglianesi and Nash 2001.) However, the potential for strategic behaviour must be assessed.

Public authorities can also support information-sharing concerning environmental management practices amongst firms through networks and other related schemes. (See Five Winds International 2000 and Danish Ministry of Trade and Industry/Ministry of Environment and Energy 2001.) Gathering and disseminating information on “best practice” may overcome information cost barriers. This is thought to be particularly important for small and medium-sized enterprises where access to information is often most restricted. (See OECD 2001A.)

On the demand side, eco-labelling and other related schemes can also help firms to realise commercial-environmental opportunities at the level of the product. More generally, as efforts to differentiate products on environmental grounds become more widespread, advertising law may have to be changed. For instance, in most countries “false claims” (including environmentally dubious claims) are regulated through general advertising law. This is the case in Germany. However, in the United States specific legislation has been introduced to deal with claims of “environmental superiority”. (Karl and Orwatt 2000)

Thirdly, and most controversially, public authorities can try to affect internal decision-making procedures within the firm more directly. As noted above, this is a very hazardous exercise and governments must enter into this area with some caution. However, it is clear that the basket of policy measures used by governments is increasing rapidly and, arguably, most of the new measures are concerned with internal decision-making processes within the firm. Examples include the following:

- Environmental management systems – by providing support (or incentives) for the development of environmental management systems, some governments are seeking to improve environmental decision-making. This is the case in the EU, with the introduction of the Eco-Management and Audit Scheme. (The case study on Netherlands Environment Product Policies discusses these issues.) More generally, many OECD countries (Netherlands, Japan and Mexico) provide “regulatory relief” for firms which have ISO 14001. (See OECD 2000C). An innovative World Bank project in Guadalajara, Mexico encourages large firms to “mentor” smaller firms in the development of EMS’s. (See World Bank 1998.)
- Self-audit policies - the US EPA’s Audit Policy uses financial incentives, by lowering fines for non-compliance discovered through self-audits.²⁷ For instance, in Australia the Queensland *Environmental Protection Act 1994* prevents a firm that is using an environmental audit scheme from being punished in case it incriminates itself. Some American states have introduced “audit privilege legislation” to address this problem. (See Coglianesi and Nash 2001.)
- Corporate Environmental Reporting –corporate environmental reporting is usually voluntary. However, Norway and the Netherlands have mandated environmental reporting. (See Kestemont

27. Although, the law may have the perverse effect (from the firm’s perspective) of increasing the likelihood of enforcement. Moreover, under American law liability is greater in the case where the violator is aware of damages generated. (See Pfaff and Sanchiricio 1999.)

and Ytterhus 1997 and Welford 1999.) In addition some countries stock exchanges require corporate environmental reports. (See Welford 1999.) However, it is widely felt that in order to be useful there is much room for improvement in this area, particularly with respect to the reform of corporate disclosure laws. (See WRI 2000b.)

- Personnel Incentives and Training – giving individuals within the firm the appropriate incentives to recognise and act upon environmental-commercial synergies is very important, but governments have little role in this area. However, by allowing for the possibility that individuals may be held responsible for environmental harms generated by companies, the government can influence personal incentives. This is the case in the United States. (See Pfaff and Sanchiricio 1999) It is also the case in Norway. Support for training in environmental management practices is also being widely proposed by many countries. (See Danish Ministry of Trade and Industry/Ministry of Environment and Energy 2001.)
- Accounting procedures – by encouraging firms to use accounting procedures which allow for the better integration of environmental costs and benefits with other aspects of the firms operations, it is hoped that firms will be better placed to recognise environmental-commercial synergies. This is not usually mandated by law, but is rather encouraged by various means such as dissemination of “best practice” guidelines. For instance, the EU has supported the Environmental Management Accounting Network. (See Welford 1999.) However, in New Jersey and Washington permit procedures have been linked explicitly to the introduction of environmental accounting practices. (See Boyd 1998.)
- Organisational structure – by seeking to affect the locus of responsibility for environmental matters within the firm some governments are directly affecting organisational structure. For instance, amongst other countries Germany mandates the appointment of an individual with responsibility for environmental matters (Gabel and Sinclair-Desgagné 1993). In the United States there are many examples of court-imposed organisational remedies (See Sinclair-Desgagné and Gabel 1996).

All of these programmes are efforts on the part of the policymaker to affect the workings of the firm. However, governments are cognisant of the fact that they are not best placed to dictate management strategies to firms. As such, this is usually done in a non-prescriptive and voluntary manner. Nonetheless, since these policies often entail the use of public financial resources and can (and should) have important consequences for firm behaviour they should be assessed and evaluated, as with any public policy.

6.2 *Specific Lessons from the Case Studies*

In addition to these general policy conclusions, lessons have also emerged from “public policy case study” reports prepared by five member countries. These review a variety of “soft” public policies which were designed to help firms improve their own environmental performance. Reflecting the nature of eco-efficiency the policies are not regulatory instruments (whether direct or indirect), but are instead policies designed to increase the responsiveness of firms to commercial-environmental opportunities. Thus, the policies include voluntary agreements, technology dissemination programmes, research and development programmes, management support schemes, etc.... (See Box 5.)

Box 5: Overview of Public Policy Case Studies

- **Australia's Greenhouse Challenge**
 - a co-operative programme initiated in 1995 between industry and government to reduce GHGs
 - well over 400 firms directly involved and a number of smaller firms allied to the programme
 - the programme will meet abatement expectations for year 2000
 - projected annual emissions savings of 23.5 Mt CO₂ relative to baseline
 - low participation from some sectors (agriculture, government, etc....)
- **Finland's Environmental Cluster Research Programme**
 - a collaborative programme initiated in 1997 between business and government to promote eco-efficiency, co-operation and environmental entrepreneurship
 - programme includes research on economy-wide material flows, firm-level eco-efficiency; and evaluation of effectiveness of environmental policies
 - brings together both producers and users of environment-related knowledge in firms, public authorities, and the research and education systems
- **Environmental Product Policy in the Netherlands**
 - applies life cycle-based analysis of products in order to formulated an integrated product policy
 - making use of the information held by firms and devising strategies to increase consumer awareness
 - focus on the specific issues faced by SME's in improving product performance focus
 - difficulties in monitoring and evaluating environmental product performance
- **New Zealand's Target Zero**
 - an industry/government partnership aiming to help participants in creating a cleaner production culture which sustains business and the environment
 - covers 20 companies in two cities from a variety of different sectors, with large representation from meat or meat by-products
 - information sharing and dissemination, consultancy contracts for LCA's, training schemes, etc...
 - reported savings of \$3.5 million/annum in material and energy inputs, with many firms reporting payback periods less than 18 months
- **UK's Environmental Technology Best Practice Program**
 - focus of the case study on the food and drinks sector – both product and process
 - particular focus on small and medium-sized enterprises (SME's)
 - information dissemination to encourage the diffusion of environmental technologies
 - use of generic and sectoral best practice guides; benchmarking guides, workshops, software packages
 - financial savings in the regions of 200,000/year, and projected total savings of 4.5 million by 2006.

In addition to the policy lessons which emerge from the individual case studies, a number of general policy lessons emerge from a comparative overview:²⁸

- The environmental policy tool box is much broader than it was 10 years ago, with much greater use of “soft” policy tools involving cooperation and partnership;
- “Soft” policies are part of a much broader policy package (including direct and indirect regulatory incentives). Thus such “soft” policy tools are complements and not substitutes for the regulatory regime;
- The introduction of such policies usually involves a great deal of cooperation between ministries of environment and industry/economics (plus others). This has resulted in a very important learning process, with greater integration of policy objectives;
- Most of the policies are dependent for success upon internal organisational responses by the firm. This is even true of those policies in which organisational issues were not addressed explicitly in the policy itself;
- Different “soft” policy tools are appropriate for different firms. Relevant distinctions include leaders and laggards, differences based upon sectoral characteristics, the nature of the environmental concern, etc....;
- Effective policies which seek to change firm behaviour must be based upon a recognition of what actually drives individual firms. A narrow focus on short-run financial incentives may be inappropriate;
- It is important to know how to encourage firms which are environmental leaders without “protecting” them in an unwarranted manner and without being captured by private interests. Thus, participation in the design of policies must be broader than just apparent “leaders”;
- There is a need to balance efforts to encourage leaders to be innovative with respect to environmental matters with the need to mainstream the benefits of such innovations. There can be considerable tension in this area since some of the commercial benefits of “leadership” are undermined by diffusion of best practice;
- Inter-firm relationships are very important in diffusing environmentally-preferable technologies and management systems. This can include “vertical” relationships (chain management) and “horizontal” relationships (benchmarking); and,
- Even those policies which involve self-regulation (e.g. voluntary environmental agreements) benefit from explicit targets and time-scales, both for the credibility of the programme itself and to provide direction for firms.

The relative importance of some of these lessons emerge more clearly in the review of the individual case studies which are discussed in Annex 4.

28. These conclusions emerged from discussions held by the contributors of the public policy case studies and others at a workshop held on May 9th, 2000 at the OECD.

7. Conclusions

It is clear that firms are starting to take environmental matters more seriously. This is due in large part to the increasingly comprehensive and effective nature of regulatory regimes in most OECD countries. Traditional regulatory functions are, therefore, certainly the most important function of government agencies responsible for environmental matters, and will continue to be so for the foreseeable future. However, increased reliance on the use of instruments which increase the value of information related to environmental performance within the firm (e.g. non-prescriptive market-based instruments and performance-based standards) should help firms to allocate their own resources more efficiently.

In addition, and as this report has tried to document, the increasing environmental sensitivity of some firms is also due to the apparent perception that in many cases there may be commercial benefits to be obtained by improving their environmental performance. Much of the evidence in this area is anecdotal, but a growing body of more formal empirical evidence appears to show that there are some significant areas in which environmental and commercial objectives may be complementary. This is hardly surprising since firms have not always had strong incentives to identify and act upon such opportunities in the past.

With fast-changing conditions (environmental preferences of consumers, regulatory conditions, technological developments, etc...), firms are unlikely to be operating at their efficiency "frontier" on a continuous basis. And nor should they be seeking to do so. Thus, given the inertia in organisation structures, communication channels and decision-making procedures, these apparent "win wins" are perhaps best understood as internal response lags. Various environmental management tools are being used to shorten these lags.²⁹

Does the government have a role to play in helping to increase the responsiveness of firms to such opportunities? Should environment ministries concern themselves with what takes place inside the firm? This report has tried to argue that there is a case for such a role and that in a rather *ad hoc* manner governments are appropriating this role in any case. Increasing attention is being paid to the specific characteristics of firms in the design of environmental policy. More controversially, support is being provided for the introduction of various environmental management tools by a variety of means, most of which are voluntary and discretionary. In a sense, environmental policy is starting to look more and more like industrial policy more generally.

This is, however, an exercise which is fraught with difficulties. In the presence of win-wins, policy must necessarily be designed in the presence of a complex mix of private (commercial) and public (environmental) interests. This complicates policy design, implementation and evaluation considerably. Policies which generate "win-wins" at the level of the individual of the firm may not be optimal policies for the economy as a whole. Moreover, even if the policy has positive welfare effects overall, it may not be the most cost-effective means of meeting the stated objectives. Thus, the apparent existence of commercial-environmental opportunities at the firm level should not be used as an excuse not to evaluate and assess the use of "softer" policy levers.

Thus, for better or worse, OECD member country governments are increasingly seeking to "go inside the firm" in their environmental policy frameworks. As such, there is a clear need to understand the

29 Nelson and Winter (1982) discuss the general case for such a view: "In a regime in which technical advance is occurring and organizational structure is evolving in response to changing patterns of demand and supply, new non-market interactions that are not contained adequately by prevailing laws and policies are almost certain to appear and old ones may disappear."

"environmental" motivations of the firm in greater depth. Further work in this area at the OECD will include a large international industrial survey, exploring the links between environmental policy design and firm-level decision-making and management systems. (See OECD 2001B.)

ANNEX 1: EVALUATION OF POTENTIAL IMPROVEMENTS IN ENVIRONMENTAL PERFORMANCE AT THE SECTORAL LEVEL

The World Business Council on Sustainable Development, the World Resources Institute and others have collected a number of case studies which report on environmental-commercial win-wins. These cases focus on past performance at the level of the firm. However, it is at least equally important to look into the future. What is the potential improvement in environmental performance within the next decades? Such an exercise is best undertaken at the sectoral level, and as such the OECD in co-operation with a number of member country governments commissioned a series of studies in six sectors: transport, food, buildings/construction, electronics, plastics, and packaging. These studies look into the possibility to reduce selected aspects of natural resource use and environmental impacts.

A1 Sectoral Potentials for Improving Environmental Performance

The studies are diverse in their approach to estimating sectoral eco-efficiency potentials. Thus, many of the estimates are pure engineering-based results, paying little attention to market conditions, either on the demand side or the supply side. Moreover, data quality is highly variable among the six sectors. For food supply, transport and housing, data are relatively accessible because these are “mature” sectors, where most OECD governments have collected relevant data for many decades. For plastics, the electronics industry and packaging less data are available, especially with respect to resource use and environmental impacts. Because of time and data constraints, most of the case studies focus primarily on energy use and a small number of specific resource flows or environmental impacts, depending upon the information available.³⁰ However, it is hoped that a review of sectoral potentials will cast some light on opportunities for improved environmental performance at the firm level.

A1.1 Eco-Efficiency Trends and Potentials for the Food Supply Chain in Sweden

The study on the food supply chain discusses the possibilities and limitations of improved environmental performance in the sector in Sweden. (Persson 1999.) As in other countries, Swedish agriculture is going through a process of restructuring, resulting in increased concentration. This is also true of the food processing and food retail industries. Transport of food products is increasing, and employment in agriculture and the food industry is declining. And finally, food consumption patterns have changed in recent years, with an increase in the consumption of meat, cheese, and processed and imported food.

Current Environmental Impacts and Trends

Environmental impacts associated with energy consumption is one of the major environmental concerns associated with the food supply chain in this sector in Sweden. Approximately one-fifth of Sweden’s energy consumption goes towards supplying food. Most of the energy is used in agriculture, households and the food industry, but transportation also consumes a large share. Moreover, energy use in

30 Three of the case studies were presented and discussed in some detail at the OECD Sydney workshop in 1999 (OECD 1999A). The following section is not intending to summarise the studies, but to highlight the major points.

the food supply chain has been increasing in recent decades. However, substantial energy efficiency gains have been achieved. For instance, the energy required to produce one kilogram of nitrogen fertiliser, and the energy intensity of agricultural buildings, heated greenhouses and refrigeration (kW/litre), has declined considerably in recent years.

During food production, pesticides and chemical fertilisers containing both phosphorous and nitrogen are used. While, these can lead to degradation of surface waters and groundwater, Swedish fertiliser application rates are below the EU average. However, nitrogen fertiliser applications are above the OECD average. The total use of phosphate fertilisers in Sweden has declined four-fold in the last 25 years. Sweden uses less pesticide on average than the rest of Europe, having reduced application rates about three-fold since the early 1980s.

In addition to environmental impacts from energy use and fertiliser applications, more than half of the total packaging in Sweden is associated with food supply. Sweden has introduced producer responsibility for packaging, which may have led to some reduction in material and energy use, and some increases in recycling rates.

Options for Improvement

The study found that technologies which are currently commercially available could lead to reductions in energy intensity throughout the food supply system. Improved refrigeration technologies is one area of potential improvement. The environmental impacts of pesticide use could be diminished by changes in the technology used to control pests (i.e. bacterial rather than chemical pesticides), and through the cultivation of more resistant crops. The use of chemical fertilisers could be reduced through changes in agricultural practices. "Precision technologies" which ensure that animals are given the exact fodder they require and that crops receive better targeted fertilisers, pesticides and irrigation water have significant potential to reduce waste and runoff. The balance between vegetable and animal production could also be improved, allowing better use of animal manure and a reduction in phosphate and nitrogen accumulation through reduced use of chemical fertilisers.

Downstream, the use of better packaging materials and distribution systems for food should decrease food waste significantly. Recycling of packages can also save energy and other resource inputs. Increased preservative radioactive treatment is a promising method to reduce waste in the food supply chain, although health and safety issues need to be adequately addressed. The use of GMOs is even more controversial. While there may be significant improvements in yields, the potentially adverse impacts on the environment (including biodiversity) and on human health need to be given due consideration.

However, in many senses reductions in the environmental impacts of the food supply chain is in the hands of the consumer. This is due to the important links between the "private" characteristics of food consumption (e.g. personal health) and "public" aspects of the means by which it is produced (e.g. environmental impact). Such a close link between private and public interests is not as important in many of the other sectors reviewed.

A1.2 Eco-Efficiency Trends in the Building and Real Estate Sector in Norway

The building and real estate sector is one of the largest sectors in Norway. (Bramslev 2000.) It includes a large number of small and medium-size enterprises. One of the remarkable features of the construction process is that user requirements are often complex and contradictory. Moreover, many of the environmental impacts are associated with building use rather than construction. In addition, the use of the building may change frequently during its life, with different technical requirements. And finally, growth

in the sector in many countries is more a function of increased living and working space per person, rather than increases in housing and office units.

Current Environmental Impacts and Trends

The sector has a significant impact on the environment. It is responsible for 40% of the energy consumption. Approximately 90% of the sector's total consumption is used in the operation phase and in particular for space and water heating purposes. During the last 30 years average energy consumption per dwelling has increased by 35%, despite the fact that houses are better insulated.

The sector is responsible for 40% of the materials (measured by weight) consumed annually in Norway. While most of this material use is benign, hazardous substances are utilised in both the construction phase and the operations phase, sometimes without any knowledge of the existence of the toxic substances and their health and environmental impacts. Moreover, due to the long-lived nature of buildings there can be considerable uncertainty about future environmental impacts.

Options for Improvement

The study found significant potentials for environmental improvements. The design of the building has a strong influence on the environmental impacts of building use, especially those impacts associated with energy consumption. On the one hand, this involves improved efficiency of dwelling fabrics and appliances. On the other hand, by switching to less carbon-intensive fuels, and through the increased use of renewable energy resources (particularly solar), the environmental load per energy unit could be further reduced. Additional reductions may be achieved by cutting heated space per person in Norway, although this is less amenable to policy intervention.

The annual consumption of raw materials could be diminished by more efficient use of floor space, extending the lifetime of buildings, and through new production and construction methods. Increased re-use and recycling of materials instead of landfilling could further extend the lifetime of the materials, although sorting of mixed demolition waste can be costly. In addition, choosing renewable and non-hazardous substances where possible would also have a positive environmental effect. Eventually, to improve the indoor and outdoor environment the use of some hazardous substances should be reduced or phased out. (See OECD 2001c and OECD 2001d.)

A1.3 Eco-Efficiency Trends and Potentials in the Electronics Industry

A third case study looked at the electronics sector in selected OECD countries. The sector is characterised by very rapid growth in output (sales have increased six-fold since 1980), short product life (new products are released approximately every six months), and fierce competition based on both performance and cost. (Ecobilan 1998) Product innovation is strong since it allows some firms to escape competition based on purely on price and to generate high profits.

Current Environmental Impacts and Trends

The in-use phase of the typical personal computer dominates its life-cycle environmental impacts, including material flows through electricity consumption. The display unit accounts for 50-60% of the energy use of a PC. However, the manufacturing stage plays a more important role in the release of hazardous materials, including toxic and ozone-depleting substances.

Electronic product lifetimes are falling. Desktop telephones in the 1970s were replaced every 12 years, but they are now replaced every 3-5 years. Early desktop computers had successive owners, like

cars, and were not discarded until the end of their physical life. However, the second-hand market is becoming less important as innovation accelerates and new equipment prices fall. For the most part, computers are now discarded before they cease to function.

The needs of the portable computer and telephone markets are leading to rapid technological development to improve energy efficiency. However, less energy-intensive devices (such as LCD screens) have not yet achieved adequate performance or low enough cost to play a strong role in the market for desktop products. While environmental performance (in production or use) is not a widely-applied criterion used for product differentiation in the current electronics market, green procurement policies introduced by some major buyers have led the industry to pay more attention to environmental impacts in their development of new products.

Options for Improvement

The study identifies a number of measures that might improve environmental performance in the electronics industry. It looks in detail at the potential for reducing the environmental pressures associated with computer video display units (VDUs). Much attention has been paid to reducing energy intensity through the use of "sleep" functions. However, improved hardware can probably achieve more. Technical improvements in VDUs can reduce energy use by 35-43%, while a shift to LCD screens would reduce both energy and material use by up to 80%.

Electronic product life could be increased by improving the availability of replacement and upgrade parts, and by designing products for easy repair and maintenance. Improving the rate of re-use and recycling in the industry depends on optimising product design for this purpose. The study found that the potential for recycling is relatively low in products made mostly from plastics, but higher in products containing a larger proportion of metals. Recycling of printed circuit boards can save money, as they contain precious metals such as gold, silver and palladium. Design for easy disassembly could lead to a reduction of recycling costs.

A1.4 Eco-Efficiency Trends and Potentials in the Plastics Industry

The study on the plastics industry focussed on the situation in Europe. The plastics industry is not a clearly defined entity, and includes a wide variety of different types and sizes of firms. (Plasticconsult 1999) Raw material inputs are produced and converted to ingredients for plastics (polymers and monomers) mainly by large, multinational petrochemical companies, although they may rely on small contractors for certain functions. In general, small firms process the raw material into products with them they supply large consumer goods companies.

Current Environmental Situation and Trends

Throughout the plastics life-cycle one of the greatest environmental impacts is the use of petroleum as material feedstock. At the end of their lives, plastics represent the bulk of material disposed to landfill. However, while this may result in landscape disamenities and other adverse effects, they do not cause significant water or air pollution as they are generally inert. Rates of plastics recycling and reuse remain very low, at around 10%, in OECD countries. In addition, the use of fossil fuels for combustion in plastics manufacturing processes contributes to air pollution, particularly greenhouse gas emissions.

Environmental trends vary among the different types of firm in the industry. For the most part, the large petrochemical companies have continued to improve their process integration and energy management in order to reduce costs. They have also introduced pollution control measures, such as eliminating chlorine as a reactant, and improving process control to reduce leakage and spills. An

increasing proportion of process water is recycled, reducing water use rates and wastewater generation. The industry is rapidly reducing its emissions of nitrous oxide (a greenhouse gas) during the manufacture of adipic acid, an input used in the production of nylon.

Processing of raw materials is also becoming cleaner. In particular, the catalysts used are becoming more effective. Indeed, such small quantities are now needed that they can usually be left in the final product, avoiding washing or stripping and the resultant waste streams. However, some harmful substances are released to the environment during downstream processing, especially in the case of thermosets, which are manufactured under relatively poorly controlled conditions *in situ* or by the manufacturer.

Potential for Environmental Improvement and Barriers

There are two main options for reducing the use of non-renewable resources and greenhouse gas emissions in the production of plastics: substitution of renewable material sources (i.e. biomass) and/or improvements in the rate of recycling of plastics. A third option for reducing fossil fuel use is to use post-consumer plastic waste as a fuel.

Ultimately, it is technologically feasible for biomass to completely replace fossil fuels as a source of hydrocarbons for plastics production. Many processes have been developed to produce synthetic fuels from wood, starch, sugar and oil crops. In many cases, it is technically easier to produce chemicals of a high level of purity from biomass than from crude oil.

The rate of plastic recycling is increasing rapidly in the European Union, due in part to the progressive application of the packaging waste directive. On current trends, recycling of post-consumer waste could reach 35-40% in Europe over the next five years. Much higher levels could be attained, but various barriers remain, such as sorting costs due to the heterogeneity of plastics in the waste stream. The authors of the case study argued that schemes based upon extended producer responsibility offer considerable potential for overcoming some of these barriers.

A1.5 Eco-efficiency Trends and Potentials in the Packaging Industry in France

Packaging is the eighth largest industrial sector, equivalent in size to the aerospace industry. (Dalt 1999) Firms in the packaging industry have evolved from manufacturers of traditional products (buckets, barrels, pots, etc....) and are distinguished largely by the materials used (glass, metal, paper, plastic). Individual companies also make components such as bottle caps and diffusers. More than 60% of the industry works with paper, cardboard and plastics. The 1990s have seen a continuing gradual trend away from traditional materials, such as wood, metal and glass, towards plastics.

Current Environmental Situation and Trends and Options for Improvement

The weight of materials required for a given packaging function has declined by 30% to 50% in the last 25 years. Material reduction trends are expected to continue, resulting from measures including: reduced thickness of packaging; development of more compact products (e.g. in washing powders); and optimisation of shapes. Conversely, while the sale of larger packages can help to reduce the mass of packaging per unit of contents, the current trend is towards smaller packages, meeting the needs of small households and more diverse consumption patterns. A survey of French companies shows that they believe the current potential for dematerialisation is about 12% (measured by weight). This may be a pessimistic estimate as incentives for the French to address environmental issues has been weak relative to other countries. For some products, the potential for dematerialisation may be in the region of 40%-50%.

In some cases it may be possible to eliminate or reduce packaging. There has been considerable interest in eliminating boxes for toothpaste tubes and other hygiene and pharmaceutical products. There is also a trend towards increased use of single-layer "refill" packaging in place of rigid boxes with internal pouches. However, this may lead to increased secondary packaging to improve protection during transport and ease of handling.

Current recycling rates in France are about 43% for cardboard and paper, 39% for glass and only 4% for plastics. While the technical potential to recycle packaging material is considerable, technical barriers limit the practical potential. On the one hand, glass and metals can in principle be recycled indefinitely. In contrast, plastics are much harder to recycle, and paper and cardboard can go through a few cycles before the cellulose fibres lose their structure. On the other hand, while metals can be separated from waste by machines, glass, paper and plastic waste still need to be separated by the consumer. Therefore, effective recycling depends on both changing consumer habits and developing effective and frequent collection systems.

The technical potential for reusing packaging is considerable. As in the case of recycling, barriers limit the extent to which that potential can be achieved, especially in household packaging. Industrial and commercial packaging (pallets, crates, barrels, etc....) is already extensively reused. Achieving high rates of re-use in the household market would demand systems for the collection of containers and space in shops for the storage of used containers, as well as designing more durable, washable and refillable containers. Plastics, cardboard, paper and wood can be incinerated with energy recovery. However, effective energy recovery and composting depend on the separation of waste. Currently, about 12% of French waste is currently used for energy recovery or composting.

Some current trends offer opportunities to reduce packaging substantially in the future. In particular, there has been a shift of some production activities from households to industry. There has also been a move towards increasing demand for services, such as the use of restaurants. The trend towards eating out provides a substantial opportunity to manage packaging, as restaurants generally buy in bulk, and offer a greater potential for realisation of economies of scale in reuse and recycling. Moreover, increased use of internet and other remote shopping could lead to less use of display packaging. Meanwhile, computerisation of logistics could contribute to effective reuse of containers, as well as recycling and recovery.

A1.6 Eco-Efficiency Trends and Potentials in the Danish Transport Sector

The final case study examined passenger car transport and relevant substitutes in Denmark. (Gudmundson and Nielsen 1999.) The study is restricted to the construction and maintenance of roads, and the consumption of motor fuel, energy for its production, materials, spare parts and energy for the production of motorcars.

Current Situation and Trends

The study identifies three major impacts from car transport: consumption of materials and energy and the emissions of CO₂. Motor fuels, including the production of the fuel, generally represent the biggest share of environmental impacts. Road construction and maintenance account for a substantial part of the consumption of materials from car transport, but their role in connection with energy consumption and CO₂ emissions is very small. In contrast, the production of motorcars and spare parts represent approximately the same share of the consumption/emission for materials, energy and CO₂.

Options for Improvement

A certain degree of improvements can be reached through the use of improved technology. For instance, more energy-efficient cars will save energy. In addition the use of electric cars should reduce local air pollutants, although overall effects will depend upon the primary energy source. Increased recycling of scrapped cars should reduce material and energy use. More fundamentally, another option for improvement is through reorganisation of transport networks with greater use of public transport and car-sharing, as well as changes in land use patterns in order to reduce travel needs and improve access to public transit terminals. A change in shopping and work habits (e.g. increased use of telecommuting, teleshopping, etc.) may create transport-related environmental benefits. Further reductions in environmental impacts would demand considerable changes in the role and function of car traffic in everyday life. Such changes are not likely to occur without significant changes in the economic system and the service and mobility levels expected from the transport system.

A2 Evaluation of the case studies

The estimated potential environmental improvements in the case studies vary widely depending on the approaches used by the analysts, on their interpretation of the word “potential”, and on the specific assumptions regarding key variables. In particular, the word “potential” is often used in different ways. The International Energy Agency, working with the Intergovernmental Panel on Climate Change (IPCC) in the early 1990s, sought to bring some clarity to the concept of potential. The IPCC published definitions of different types of greenhouse gas mitigation potential, which are reproduced in Box A.1.

Box A.1 Technical, economic and market potential

Technical Potential—The amount by which it is possible to reduce GHG emissions or improve energy efficiency by using a technology or practice in all applications in which it could technically be adopted, without consideration of its costs or practical feasibility.

Economic Potential—The proportion of the technical potential for GHG emissions reductions or energy efficiency improvements that could be achieved cost-effectively in the absence of market barriers. The achievement of the economic potential requires additional policies and measures to break down market barriers.

Market Potential—The proportion of the economic potential for GHG emissions reductions or energy efficiency improvements that currently can be achieved under existing market conditions, assuming no additional policies and measures are introduced.

Source: IPCC (1996)

However, there remains room for disagreement. For example, evaluating the economic potential depends on the definition of “cost-effective” adopted in the studies. The IPCC (1996) report evaluated the economic potential for GHG mitigation through investment in new technology, adopting a variety of payback periods and discount rates. Engineering-based arguments are used to support the idea that energy savings of 10% to 40% are cost-effective. However, many of these estimates ignore administration (and other “hidden” costs) and the real opportunity cost of capital within the firms. In other cases, current best (cost-competitive) practice is often taken as an indication of the economic potential. However, this ignores questions of firm heterogeneity discussed below. Indeed, economic arguments are often used to support the idea that, if more energy-efficient technology were cost-effective for its users, it would already have been implemented. (See Section 3 for a more detailed discussion of these issues.)

Of the three definitions, the sectoral case studies are best understood as reviews of “technical potentials”. As such, market conditions (and indeed financial considerations) are not addressed at all or only in a rather cursory manner. However, the reports do generate some valuable insights:

- Firstly, changes in the environmental impacts of different sectors is largely in the hands of the consumers. It is the consumer who has the possibility to support environmental measures through purchasing decisions. However, this has very different implications for different sectors, depending upon the extent to which improved environmental performance affects the characteristics of goods and services consumed. For example, in the building and real estate sector the size of the used floor space for housing and working has an effect on energy consumption. In the packaging sector the extent of recycling is highly dependent on the efforts the consumer makes to separate the different types of packaging. And finally, substantial savings in energy and resources from road transport can only be achieved by changing the role of the car in everyday life. However, in all of these cases the scope for environmental improvement is constrained (or facilitated) by the underlying preferences of consumers.
- Secondly, in some cases improved environmental performance can be achieved through technical development which does not affect the nature of goods and services in a significant way. All case studies emphasise that the more frequent use of existing energy-saving technologies or their development will contribute to energy savings on a large scale. Another option for improvement, especially in the building and real estate sector is seen in the substitution of hazardous substances for non-hazardous materials. Many materials containing these substances could be replaced without jeopardising the quality of the product. These changes are largely a function of the cost-effectiveness of alternative materials and resources.
- Thirdly, organisational improvement within the sector was found to be an option for improvement. For instance, in agriculture environmental impacts from the use of fertilisers and pesticides could be reduced by greater precision in the application of inputs, without investing in advanced technologies. In other cases, such organisational improvements will cut across firms. Setting up an extended producer responsibility scheme for post-consumer waste (i.e. a deposit-refund scheme) may lead to cleaner types of plastics and may thereby increase the reuse and recycling of plastics. In the building and real estate sector, better co-operation between the architect, builder, landlord, and tenant during the planning and construction phases could lead to a reduction in the life-cycle costs of the building.

These three broad lessons indicate that it is clear that we need to go below the sectoral level and look at the firm itself.

ANNEX 2: REVIEW OF EMPIRICAL EVIDENCE ON FIRM CHARACTERISTICS AND ENVIRONMENTAL PERFORMANCE

The **size of the firm** is thought to be important for a number of reasons. Firstly, larger firms are often better placed than smaller firms to improve environmental performance because they are better able to reallocate resources and personnel. This is particularly true if there are economies of scale associated with improved performance. Secondly, they may also be more subject to potential environmental liability due to their “deep pockets” and regulatory enforcement due to their visibility.

The evidence seems to support this view. In a review of the environmental performance of transnational corporations, Levy (1995) found that company size (expressed in terms of revenue) had a significant and positive effect on a variety of indicators of environmental management policies. Similarly, a study of Mexican firms undertaken by Dasgupta et al. (1997) found that larger firms (expressed in terms of numbers of employees) are more likely to introduce environmental management systems. In a survey of electronics firms in Quebec, Lefebvre et al. (1995) find that firm size is significantly and positively correlated with a number of self-reported indicators of environmental performance. This was also confirmed by a more informal study carried out in Australia by the Monash Centre for Environmental Management (1999). Looking directly at emissions (“toxic waste releases”) from the chemical industry in the United States, Streitweiser (1994) finds that emissions increase by only 4% as the scale of the plant (in terms of employees) increases by 10%. Konar and Cohen (1997) confirm this result, but find that the relationship is non-linear with the effect falling for larger firms. In a study of Korean firms, Aden, Kyu-Hong and Rock (1999) found that firm size (number of employees) had a positive and significant effect on plant-level abatement expenditures.

There have also been two Canadian studies. Henriques and Sadorsky (1996) found that Canadian firms which were listed on the stock exchange were more likely to have environmental plans in place. And finally, Sharma (2000) found that amongst 99 Canadian oil and gas companies the size of firm had a significant influence on self-assessments of the degree of “pro-activeness” of the firm’s environmental strategy.

One of the few studies to look at the relationship between firm characteristics and environmental innovation (Hemmelskamp 1999), found that in Germany it is the very small and the very large firms which are most likely to innovate. In a more informal study in Italy, Malaman (1996) confirms that large firms are more likely to adopt innovations. In terms of programme participation, Arora and Cason (1996) found that larger firms are more likely to participate in the US EPA’s voluntary 33/50 programme, but that this effect tends to decrease as firm size increases. DeCanio and Watkins (1998) reach a similar conclusion for the EPA’s “Green Lights Programme”. The only countervailing results is obtained in a study of compliance of the US steel sector with air pollution regulations (Gray and Deily 1996), where scale has a negative effect on compliance.

The **capital stock vintage** is also thought to be important since it is widely perceived that newer vintages are likely to be “cleaner”. Even if firms face significant demand-side pressures to improve their environmental performance, they may be more reluctant to invest in new capital if existing capital has a long life. This is particularly important if innovations are “embedded” in production processes generally, and not just “add-ons” such as end-of-pipe equipment.

The evidence is, however, ambiguous. The Mexican study cited earlier found no relationship between capital vintages and environmental performance. (See Dasgupta et al. 1997). Two studies from the United States find contradictory evidence. In a study of the American electricity supply industry, Maloney and Brady (1988) find that the age of the capital stock is significantly and positively related to

emissions. Incidentally, they also find that the “new-source bias” of Clean Air Act regulations increased the average age of the capital stock, generating a perverse environmental effect. Nelson et al. (1993) dispute this result, finding no relationship between the age of the capital stock and emission rates. This is confirmed by Gray and Deily’s (1996) study of air pollution emissions from American steel plants and Konar and Cohen (1997) study of toxic emissions from all manufacturing facilities.

The degree of **exposure to international markets** is thought to have both a demand-side effect and a supply-side effect, resulting in improved environmental performance. On the supply side an open trading regime may increase access to environmentally preferable technologies and inputs. It may also result in an improved allocation of resources generally. And finally, exposure to international trade may increase pressures to meet the environmental demands of overseas markets. This is however, dependent upon the relative stringency of regulations between trading partners.

However, once again the evidence is somewhat ambiguous. In his study of transnational corporations Levy (1995) finds that the firm’s trade ratio (exports/output) has a negative and significant effect on some indicators of environmental management. In their study of Mexican firms, Dasgupta et al. (1997) find no clear evidence of a positive link between the trade-intensity of the firm with OECD countries and environmental performance. This is particularly significant since Mexico is at the lower end of the OECD income scale and might be thought to exhibit this effect most strongly. However, the evidence for firms and plants in non-OECD countries generally supports the conclusion that trade with OECD countries tends to result in improved environmental performance. (See Johnstone 1998 for a review.)

Moreover, there is some evidence in terms of technological change which supports the hypothesis that tradeability results in improved environmental performance. Thus, Malaman (1996) finds some links between tradeability and environmental performance in Italy. In two cross-sectional studies both Wheeler and Martin (1992) and Blackman and Boyd (1995) looked at the steel industry and found that diffusion of less environmentally damaging technologies was faster and deeper in “open” economies. And finally, Lefebvre et al. (1995) report significant positive correlations between export ratios and various indicators of environmental performance for electronics firms in Quebec.

Differences in the **geographical origins of capital** have also been examined, with the hypothesis that firms from countries with strict regulations will “export” cleaner technologies when they invest abroad. The more specific hypothesis in this case is that OECD-based firms will tend to transfer “cleaner” technologies developed in their home markets in their practices overseas. Since differentiation in production practices generates costs, firms will tend to “overcomply” in countries with less stringent regulations in order to realise the economic benefits of standardisation. Moreover, as with the role of consumer pressure through international trade, this would have positive environmental consequences if foreign shareholders tended to demand a rather higher set of environmental standards. Even for countries with similar regulatory systems it is sometimes felt that “foreign” firms may be better environmental performers since they may be more visible targets.

Levy (1995) finds that transnationals with headquarters in Europe and Japan are significantly less likely to have environmental information policies in place than TNCs with headquarters in the United States. Moreover, for plants of Japanese TNCs based in the United States there is a significant and positive effect on toxic emissions. In their more informal study of Australian firms, the Monash Centre for Environmental Management (1999) find that foreign firms are more likely to have environmental management systems in place than Australian firms. Johnstone (1998) reviews the evidence for non-OECD countries, which generally supports the view that firms with headquarters in OECD countries transfer their higher environmental standards overseas.

More surprisingly, in their study of Mexican firms, Dasgupta et al. (1997) find no clear evidence of a positive link between firms originating from OECD countries and their environmental performance. This negative result is confirmed by two studies in Asia: Hartman, Huq and Wheeler (1995) find no evidence of foreign ownership having a positive effect on observed abatement amongst pulp and paper plants in Bangladesh, India, Indonesia and Thailand; and, in a study of BOD emissions from manufacturing plants in Indonesia Pargal and Wheeler (1995) also find no evidence to support the assertion that foreign ownership results in improved environmental performance.

In a related vein, the **institutional sources of equity** are also thought to affect environmental performance. In particular it is often argued that firms which have to respond to shareholders are more likely to improve their environmental performance. This effect is thought to be increasing in importance as shareholders become more sensitive to environmental concerns. For instance, the results of the Henriques and Sadorsky (1996) study on the determinants of a firm's likelihood to adopt an environmental plan indicate that shareholder pressure has a positive, but relatively unimportant effect. Dasgupta et al. (1997) find that Mexican firms with public shareholdings are more likely to have environmental management systems. DeCanio and Watkins (1998) find that the more narrow the ownership of shares amongst management, the less likely firms are to participate in the EPA's Green Lights Program.

Also in a related vein it is argued that **capital availability** may also have an effect on environmental performance. Since improved environmental performance often entails capital investment, firms which are more constrained may be less likely to undertake the investment. Thus, with imperfect capital markets firms which rely upon internal sources of finance are more likely to adopt improvements in environmental performance than those which rely upon external sources. Moreover, improved environmental performance may, in itself give greater access to capital markets as "green" funds grow in importance.

Henriques and Sadorsky (1996) find some support for this hypothesis with the sales/asset ratio positively influencing the probability of a firm developing an environmental plan. Further supporting the hypothesis, DeCanio and Watkins (1998) find a negative relationship between liquidity and the rate of return required to undertake an energy-efficiency investment under the Green Lights Program. In a separate study DeCanio (1998) finds that firms which are dependent upon loans need a longer payback period. The only counter-intuitive result is that of Gray and Deily (1996), which finds a negative and significant relationship between American steel firms' gross rate of return and compliance with Clean Air Act regulations.

It is also argued that **public authorities** are less likely to improve their environmental performance relative to private firms. This might arise because enforcement tends to be weaker (which is supported by a number of studies) or because there are no clear avenues for demand-side pressures. As indirect support for this hypothesis a number of studies find that public authorities tend to be worse environmental performers. For instance, DeCanio (1998) finds that American public authorities require a higher rate of return than firms before they will invest in energy efficiency improvements. Similarly, Hartman et al. (1995) find that publicly-owned pulp and paper plants in four Asian economies abate less and Pargal and Wheeler (1995) find that publicly-owned manufacturing plants in Indonesia have higher BOD emissions.

The firm's **proximity to final consumers** is also thought to have a positive effect on environmental performance. This hypothesis is based upon the belief that consumers are best-placed to exert influence over the environmental performance of firms and as such firms which are in direct contact with final consumers will be more likely to improve their environmental performance than firms which sell to other firms. In the latter case, the environmental preferences of consumers may not be transmitted up the supply chain. Unfortunately, the evidence in this area is limited. However, in their study of the EPA's 33/50 programme Arora and Cason (1996) did find that proximity to final consumers (proxied by advertising/sales ratios) positively affected participation rates. In their study of electronics firms in

Quebec, Lefebvre et al. (1995) found that there was a positive correlation between those firms who sold more of their output directly to final consumers and a number of self-reported indicators of environmental performance. In his study of 99 Canadian oil and gas companies Sharma (2000) also found that exposure to retail markets had a positive influence on the firm's environmental strategy.

And finally, the diversity of a firm's product lines is also thought to affect environmental performance. This hypothesis is based on the assumption that narrow firm product lines tend to decrease the cost of identifying and acting upon measures which improve environmental performance. In her study of the American Chemical industry Streitweiser (1994) finds support for this hypothesis, with increased product diversity resulting in increased toxic releases. Gray and Deily (1996) also find some support for this hypothesis in their analysis of the American steel industry, insofar as less diverse firms are marginally more likely to comply with Clean Air Act regulations.

ANNEX 3: RESULTS FROM EBEB ESTIMATION

Logit Estimation of Probability of Having an EMS

	Predicted			% Correct
	No	yes		
Observed				
no	903	213	80.91%	
yes	394	455	53.59%	
	Overall			69.11%

Variable	B	S.E.	Wald	df	Sig	R	Exp(B)
BELGIUM	.8633	.1593	29.3620	1	.0000	.1009	2.3710
NETHERLA	1.0915	.1420	59.1101	1	.0000	.1458	2.9787
NORWAY	-.6658	.1692	15.4884	1	.0001	-.0708	.5139
PORTUGAL	-.9191	.2094	19.2661	1	.0000	-.0802	.3989
SPAIN	.9962	.2615	14.5100	1	.0001	.0682	2.7080
FUELPD	1.1466	.4342	6.9733	1	.0083	.0430	3.1474
Q2#EMPLS	.0001	.0000	5.2156	1	.0224	.0346	1.0001
Q3MULTI	.8986	.1215	54.6728	1	.0000	.1400	2.4562
Q4QUOTE	.5021	.1423	12.4498	1	.0004	.0624	1.6522
Q146COST	-.1749	.0464	14.2355	1	.0002	-.0675	.8395
Constant	-.9160	.1602	32.7088	1	.0000		

OLS Estimation of Determinants of Environmental Performance

OLS ESTIMATION (HETEROSKEDASTICITY-CONSISTENT COVARIANCE MATRIX)
 1614 OBSERVATIONS DEPENDENT VARIABLE = Q8ENVOBJ

R-SQUARE = 0.1416 R-SQUARE ADJUSTED = 0.1330

VARIABLE NAME	ESTIMATED COEFFICIENT	STANDARD ERROR	T-RATIO 1597 DF	P-VALUE	PARTIAL CORR	STAND'D COEFF.	ELAST. AT MEANS
EMSINST	1.2486	0.2062	6.056	0.000	0.150	0.1829	0.1666
FRANCE	-0.65578	0.2256	-2.907	0.004	-0.073	-0.0795	-0.0063
NETHERLA	-0.52625	0.0978	-5.380	0.000	-0.133	-0.1499	-0.0346
SWEDEN	-0.51468	0.0998	-5.154	0.000	-0.128	-0.1325	-0.0259
TEXTILES	-0.54088	0.1257	-4.302	0.000	-0.107	-0.1101	-0.0157
LEATHER	-0.77049	0.2978	-2.587	0.010	-0.065	-0.0605	-0.0031
CHEMPD	0.39719	0.1267	3.135	0.002	0.078	0.0705	0.0085
RBBRPLST	-0.42694	0.1527	-2.797	0.005	-0.070	-0.0668	-0.0070
ELECPD	-0.61313	0.1435	-4.271	0.000	-0.106	-0.1014	-0.0113
MACHEQPN	-0.37790	0.1113	-3.396	0.001	-0.085	-0.0806	-0.0122
Q132CIMG	0.26486	0.0628	4.215	0.000	0.105	0.1122	0.3266
Q136NEW	0.10632	0.0547	1.943	0.052	0.049	0.0491	0.1112
Q137OWNS	0.18470	0.0610	3.026	0.003	0.076	0.0873	0.2064
Q1311SPR	-0.11015	0.0457	-2.408	0.016	-0.060	-0.0589	-0.0933
Q1312MGT	0.14235	0.0659	2.157	0.031	0.054	0.0637	0.1644
Q2#EMPLS	0.00003	0.0001	2.324	0.020	0.058	0.0740	0.0053
CONSTANT	0.72373	0.3046	2.376	0.018	0.059	0.0000	0.2205

ANNEX 4: LESSONS FROM THE PUBLIC POLICY CASE STUDIES

Australia's Greenhouse Challenge³¹

Australia's Greenhouse Challenge is a "voluntary agreement" designed to encourage firms (and to a lesser extent public authorities) to help Australia meet its objectives for climate change under the Kyoto Protocol. (See AGO 1999) Initiatives undertaken include fuel switching, process changes, carbon sequestration, investment in energy-efficient lighting and capital equipment, recycling, and improved maintenance and operations. It has been estimated that the programme will result in 23.5 megatons of CO₂ equivalent per annum. This is thought to represent a savings of 16% relative to the baseline, although it is recognised that forecasting "business as usual" is a hazardous exercise.

The study is particularly important since voluntary agreements are becoming increasingly common in OECD countries. (See OECD 1999B for a recent review and assessment.) Their effectiveness relative traditional policy instruments (direct regulation or market-based instruments) has been assessed and it is clear that performance varies and that a number of conditions need to be met if they are to be effective. However, the discussion of Australia's Greenhouse Challenge in this report will not focus on their overall effectiveness. Rather it will place the agreement in the context of how they may help firms to become "eco-efficient" and realise "win-wins".

To some extent, the very notion of a voluntary agreement hinges upon the existence of "win-wins".³² However, by placing the firm-level initiatives in the context of a more formal arrangement, voluntary agreements may help to ensure that a large number of firms realise these opportunities. Sharing of information and peer pressure may increase the responsiveness of firms. Moreover, requirements for reporting and verification have helped firms identify environmental-commercial opportunities. In addition, in the Greenhouse Challenge, as in other agreements, the government has committed itself to advertising the involvement of firms. This means that firms can realise commercial-environmental synergies from both the supply side (cost savings) and the demand side (product differentiation and firm branding). However, it is not clear that this has been an important inducement.

Similar to performance standards or market-based instruments, the agreement has allowed for a more flexible approach to meeting environmental objectives. Since the agreement is not prescriptive firms have an incentive to identify and act upon environmental-commercial synergies. However, perhaps the most significant point about the programme is the importance that it attaches to "management and cultural change". A survey of the participants revealed the following benefits:

- Changes in decision-making processes within the firm, resulting in better integration of environmental concerns;
- Increased managerial commitment to environmental concerns from the high-level management, including the CEO since they must sign agreements;
- Increased employee awareness of environmental concerns (and how to improve environmental performance)

31. This section is based upon discussions with Malcolm Forbes, Sustainable Industries Branch, Environment Protection Group, Environment Australia.

32. This is not true if firms are threatened by regulatory action in the absence of "voluntary" improvements in environmental performance. In this case it is not clear that the agreement is unambiguously "voluntary".

- Improved quality and channelling of environment-related information flows (including accounting procedures) within the firm; and,
- Increased use of incentives to encourage employees or business units to engage in greenhouse abatement activities.

All of these are significant within the context of the realisation of the targets set in the programme. More importantly, they are likely to have positive consequences for other environmental concerns, and indeed management practices generally.

In addition, the programme paid very close attention to the different capacities and requirements of different firms (and public agencies). Thus a special programme was developed for “small and medium enterprises” (Greenhouse Allies). Exploiting the supply links between small and large firms, this was designed as a partnership to help mainstream some of the environmental benefits being realised by those large firms which were environmental leaders.³³ In addition, through another programme (Managing Energy for Profits) medium-sized firms could gain access to external technical expertise which they were unlikely to possess in-house. Even some of the larger firms have stressed the importance of this role. The role of industry associations through “facilitative” agreements has also been important in providing firms a context in which they can share information which generates both environmental and commercial benefits.

From the government’s perspective, the programme has been expensive, with twenty full-time Environment Australia staff involved. Some of these costs are likely to fall (or be borne by the firms themselves) through the increased use of industry associations. Recently, the relationship between the Greenhouse Challenge and potential new regulations has become of increased importance, with firms urging the government to protect those who have undertaken initiatives voluntarily. Some companies have not yet joined the Challenge because of fears that they will be disadvantaged with the introduction of future policies, particularly if a tradeable permit system is applied.³⁴

However, the programme has been successful in helping officials at Environment Australia get a better understanding of firm operations and abatement opportunities. This has been helpful in policy design more generally. It has also encouraged greater co-operation between Environment Australia and other ministries, resulting in a greater recognition and understanding of overall government policy objectives.

New Zealand’s Target Zero³⁵

New Zealand’s Target Zero was introduced in 1997 and the first stage ran through to 1999. It was initiated by New Zealand’s principal electricity supply firm. It is a government-industry collaboration to implement waste minimisation through training and project implementation. The programme was funded by both governments (central and local) and the firms themselves. The programme was made up of two “information-sharing clubs” in which participating firms sought to identify and implement opportunities to reduce waste flows. External technical and administrative assistance was also provided, including demonstration projects. It has been decided to extend the programme nationally, a good indication of its success.

33. Although only 5% of surveyed firms have used the programme to exercise influence over suppliers – e.g. by only sourcing from other programme participants.

34. Since initial permit allocations are likely to be “grandfathered”, emission reductions undertaken today may reduce future permit allocations.

35. This section is based upon communications with Richard Gordon, Landcare Research, New Zealand.

The usefulness of various aspects of the “training” programme were assessed by the participants. The club approach was ranked highest, followed by co-ordination with local government/electricity company staff, student assistance with waste audits, consultant inputs and technical assistance. Thus, the role of the “clubs” seems to have been particularly important since the ideas were mainly generated by the firms themselves. Since they are better placed to understand opportunities and constraints than external bodies, this was thought to be very important. Moreover, even for the demonstration projects, the organisations were from the same regions as the demonstration organisations, conducted similar activities, and were of similar sizes. While the role of external consultants was clearly helpful, the sharing of information with other firms was seen to be of particular importance.

The focus of firm efforts was clearly on “supply-side” win-wins. Very few firms saw the programme as an opportunity to differentiate their products environmentally or to tap new markets, with the emphasis being more on cost savings through reduced waste generation, water use, and energy consumption. However, the project also generated more general increases in productive efficiency. For instance, material input savings were the single largest source of savings. This reflects the close links which exist between general increases in productive efficiency and environmental benefits. It is felt that more fundamental innovations in production processes and products are likely to feature more prominently in the second-stage of the project.

Moreover, it must be emphasised that the rates of return were very high for most of the projects to be implemented, with payback periods of less than 18 months, and in some cases almost immediate. In one case a firm reported savings equal to 4.7% of turnover, with 10 firms reporting savings greater than 0.4%. On the one hand, this indicates some of the potential opportunities. On the other hand, nine out of 23 firms did not undertake any investment whatsoever despite the support provided. While it is possible that these firms had not identified any profitable investments, given the low payback periods for the other firms it may also indicate just how strong the pre-existing barriers are to realising win-wins.

Thus, understanding of these barriers is key. When the firms were surveyed it was found that management support and institutional support structures were thought to be adequate at the outset of involvement in the programme, once they became involved the necessary level of support proved to be greater than anticipated. In particular, many employees felt that the lack of support from management was a decisive factor in blocking potential improvements. A number of other factors were seen to be important determinants of success. For instance, in a comparison of those firms involved in the programme with a control group, it was found that the programme was instrumental in encouraging staff to identify opportunities for environmental improvements and ensuring that environmental management systems were not *ad hoc*. Moreover, the reduced emphasis on a compliance-driven approach had the effect of “mainstreaming” environmental concerns within the firm.

The United Kingdom’s Environmental Technology Best Practice Programme³⁶

The Environmental Technology Best Practice Programme is explicitly targeted toward the realisation of “win-wins”, seeking to identify and disseminate information on means by which firms can improve environmental and financial performance concurrently. The premise is that firms do not have access to the information which would allow them to realise these opportunities. This is not necessarily evidence of a market failure since acquiring and processing information is a cost like any other. However, by generating and disseminating the information at a larger scale, the programme may realise economies of scale and help those firms (particularly smaller ones) for which information costs are particularly high.

³⁶ This section is based upon communications with Douglas Robinson, Department of Trade and Industry and Mike Walker, Department of the Environment, Transport and the Regions.

The project focuses on technology diffusion, helping firms follow in the wake of environmental “leaders”. The following tools are used:

- Environment helpline
- Publications (good practice guides, benchmarking guides, technical/trade articles, and case studies)
- Conferences and seminars
- On-site consultancy

However, perhaps most interesting is the development of software for environmental management tools, clearly recognising the link between technologies and organisational issues.

The programme has a clear focus on supply-side opportunities. Overall it has been estimated that the programme generates savings of approximately £100 million annually, but it is foreseen that this will rise to over £300 million by 2010. The objective is to have a rate of return of 10:1 for private financial gains relative to public expenditures. It has resulted in a great deal of co-operation and mutual learning between the Department of the Environment and the Department of Trade and Industry.

The case study looked at the experience of the food and drinks sector, which is particularly interesting due to the heterogeneity of the sector and the preponderance of small and medium enterprises. The programme provides the food and drink sector with guidance on a variety of cost-effective means to reduce environmental impacts. Fourteen projects have been specifically undertaken for the sector, with the majority being “good practice” guides or case studies. In addition by late 1999, well over 1200 firms in the sector had used the ETBP helpline and over 2000 firms had received programme literature or attended conferences. Estimated savings for the sector are projected to just under £5 million per annum by 2006.

The two biggest concerns cited by firms in the sector in an “attitudes and barriers” survey were packaging waste and liquid effluent. Material inputs (energy, water, etc...) did not feature prominently, but this may be due to the fact that these are not perceived as “environmental” concerns by those surveyed. The programme has responded to these concerns by providing guidance that also helps manage the requirements and costs of relevant regulations, reflecting the potential gains to be realised from increasing the responsiveness of firms to existing regulatory requirements. Thus, in some senses the programme is serving most effectively as a complement to other environmental policies.

Finland’s Environmental Cluster Research Programme³⁷

Many OECD countries have research programmes targeted toward environmental improvements. In effect, governments are seeking to “bend” the direction of technological change in a way which reduces environmental impacts. Finland’s Environmental Cluster Research Programme is an example of such a programme. While the project covers a number of general areas found in other research programmes, the programme pays particular attention to the links between research and the marketplace, seeking to support innovations which are both commercially profitable and environmentally beneficial. The aims are three-fold:

- Increase eco-efficiency by saving environmental and natural resources through the use of life-cycle analyses;
- Promote environmental entrepreneurship by developing environmental know-how and management into products; and,

37 This section is based upon communications with Antero Honkasalo, Ministry of the Environment, Finland.

- Intensify co-operation between researchers and research users, and between public funding organisations.

The programme brings together four Finnish governmental agencies (Ministry of the Environment, National Technology Agency, Ministry of Trade and Industry, and the Academy of Finland). There are also links with the Forestry Research Programme, the Finnish National Development Programme, and the Foodstuff Cluster Research Programme. This degree of cooperation is particularly important in the area of project assessment since officials from different ministries will have different criteria for project selection, reflecting their ministries mandates.

In early 2000 there were a total of 60 projects which had received financing, with a total annual budget of \$US 14 million. The largest recipient areas are “eco-efficiency of production processes and products” (2.3 million EUR) and “material flows and life cycle analyses” (2.0 million EUR). However, other areas of direct relevance to commercial-environmental synergies include “development of eco-export and marketing” (0.7 million EUR) and “environmental eco-management” (0.7 million EUR).

In order to bridge some of the gaps which exist between research and the market, the programme seeks to involve both research units and private enterprises. There are 180 of the former involved and 70 of the latter. Of the 60 applications which have been accepted, 16 are lead by representatives of private firms. In order to further tighten the links between research and the marketplace, technology “users” are actively involved in a number of the projects. This is very important. However, in general the role of the private sector has not been as important as had been hoped. This is certainly at least partly a reflection that all of the results of the research are public property, reducing commercial incentives.

And finally, as with all publicly-funded research programmes there is a tension between the benefits of “bending” the direction of technological change in a desired manner and the “costs” of having to pick winners. In the Cluster Programme the most difficult problem has not been to avoid excessively “risky” projects, but rather how to encourage the applicants to take more risks. Arguably, the emphasis on marketability may be generating this bias, with a greater emphasis on incremental technological changes with clear commercial implications at the expense of more radical innovations in which market assessments are more uncertain.

Recently, the general objectives of the programme have been shifted away from applied research and toward more general increases in the “knowledge base”. One of the key areas is sustainable development and the information society. The studies are concentrated on the environmental impacts of the development of information technology in the following fields: lifestyles and cultural changes, consumption habits, e-commerce in consumer goods, replacement of products with services and the management and processing and dissemination of environmental knowledge. All of these projects are aimed to make it possible to evaluate the eco-efficiency potential of the major production sectors of the Finnish economy, and the distinction between the different stages of the life cycle and the chain of production. It is hoped that they will form a sound scientific basis for Finnish product policy. This will then help enterprises to optimize their R&D strategies and the public authorities to develop environment-related product policies which combine the objectives of industrial and innovation policies.

Netherlands' Environmental Product Policy³⁸

The Netherlands was amongst the first countries to introduce product-oriented environmental policies. The policy is designed to bring about reductions in the environmental impact of various products. (See Klinkers et al. 1999 and van Berkel et al 1999.) It was felt that the focus on products rather than production processes would allow for greater integration of different environmental problems in a single policy. It was also felt that it was more suited to a “cradle-to-the-grave” approach to environmental policy.

Initially targeted toward consumers with a strong emphasis on information provision, after meeting resistance from industry the policy was redirected toward the production chain itself with an increased emphasis on product-oriented management systems (POEMS). Consistent with the objectives of “eco-efficiency”, the programme explicitly links financial and environmental concerns. It also stressed the importance of internal organisation. Thus, environmental managers, research and development teams, purchasing departments and marketing departments are involved. It is felt that this will encourage more integrated decision-making within the firm.

The programme is designed to encourage firms to adopt a standardised management tool which will help different actors up and down the production chain improve the environmental performance of their products. It is entirely voluntary. Indeed, the government explicitly sees its role as one of encouragement, facilitation and co-ordination. This is achieved through financial support for product development, environmental information exchange systems, provision of credit for “start-up” costs, green procurement policies, and other mechanisms. Particular attention has been paid to the needs of small and medium enterprises.

Lessons learned thus far include the following:

- Target firms that have a strong incentive to develop and implement product-oriented environmental management systems and to influence others;
- Active managerial involvement and effective internal organisational structures are key to success at the level of the firm;
- The success of the programme is greatest in sectors in which there is an apparent threat of future regulatory requirements; and,
- It is important to ensure that the tools promoted (e.g. LCA) are consistent with the resources available to the firm.

However, perhaps most controversially, it is also felt that the success of the project is determined in part by the existence of government subsidies. This reflects the complexity of policy design when public and private interests are closely intermingled. It is also felt that the programme is not sufficient in and of itself to realise necessary environmental objectives, but that it must be seen as part of a broader policy programme.

38. This section is based upon discussions with Henk Wijnen, Ministry of Housing, Spatial Planning and the Environmet, Netherlands.

REFERENCES

- ANDREWS, RICHARD N. L. ET AL. (2001) "Environmental Management Systems: History, Theory and Implementation Research" in University of North Carolina/Environmental Law Institute *Drivers, Designs and Consequences of Environmental Management Systems* (Chapel Hill: University of North Carolina)
- ARORA, SEEMA AND TIMOTHY N. CASON (1996) 'Why do Firms Volunteer to Exceed Environmental Regulations? Understand Participation in EPA's 33/50 Program' in *Land Economics*, Vol. 72, No. 4, pp. 413-432.
- AUSTRALIAN GREENHOUSE OFFICE (1999) *Greenhouse Challenge: Evaluation Report* (Canberra: Australian Greenhouse Office)
- BERKEL, RENE VAN, MICHELA VAN KAMPEN AND JAAP KORTMAN (1999) 'Opportunities and Constraint for Product-Oriented Environmental Management Systems' in *Journal of Cleaner Production*, Vol. 7, pp. 447-455.
- BLACKMAN, ALLEN AND JAMES BOYD (1995). 'The Usefulness of Macroeconomic Statistics in Explaining International Differences in the Diffusion of Process Innovations' (Washington, D.C., Resources for the Future Discussion Paper 95-10)
- BOYD, JAMES (1998) 'Searching for the Profit in Pollution Prevention: Case Studies in the Corporate Evaluation of Environmental Opportunities' Washington D.C.: Resources for the Future Discussion Paper 98-30.
- BRAMSELV, KATHARINA T. (2000) "Eco-Efficiency in the Building and Real Estate Sector: Realizing the Potential of Environmental Alternatives" (Oslo: Grip Centre/OkoBygg).
- COGLIANESE, CARY AND JENNIFER NASH, eds. (2001) *Regulating from the Inside: Can Environmental Management Systems Achieve Policy Goals* (Washington D.C.: RFF, 2001).
- CORBETT, CHARLES AND LUK VAN WASSENHOVE (2000) 'Environmental Issues and Operations Strategy' in H. Folmer and H. Landis Gabel (eds.) *Principles of Environmental and Resource Economics* (Cheltenham: Edward Elgar).
- CORMIER, DENIS, MICHAEL MAGNAN AND BERNARD MORARD (1993) 'The Impact of Corporate Pollution on Market Valuation: Some Empirical Evidence' in *Ecological Economics*, Vol. 8, pp. 135-155.
- DALT/IFEC (1999) "Eco-Efficiency Trends and Potentials - Packaging Industry Case Study" (Paris: Strategic Design, New Product Definition, French Packaging Institute, mimeo.)

- DANISH MINISTRY OF TRADE AND INDUSTRY/DANISH MINISTRY OF ENVIRONMENT AND ENERGY (2001) *Routes to Green Industrial Development in Denmark* (Copenhagen: Danish Ministry of Trade and Industry)
- DASGUPTA, SUSMITA, HEMAMALA HETTIGE AND DAVID WHEELER (1997) 'What Improves Environmental Performance?: Evidence from Mexican Industry' (Washington D.C.: World Bank, Development Research Group, mimeo)
- DECANIO, STEPHEN J. (1998) 'The Efficiency Paradox: Bureaucratic and Organisational Barriers to Profitable Energy-Saving Investments' in *Energy Policy*, Vol. 26, No. 5, pp. 441-454.
- DECANIO, STEPHEN J., AND WILLIAM E. WATKINS (1998) 'Investment in Energy Efficiency: Do the Characteristics of Firms Matter?' in *Review of Economics and Statistics*, Vol. 90, No. 1, pp. 95-107.
- DENI GREENE CONSULTING SERVICES (1998) "Carrots, Sticks and Useful Tools – A Study of Measures to Encourage Cleaner Production in Australia" (North Charlton, Australia).
- DITZ, DARYL AND JANET RANGANATHAN (1997) *Measuring Up: Toward a Common Framework for Tracking Corporate Environmental Performance* Washington, D.C.: World Resources Institute.
- DIXIT, AVINASH K. AND ROBERT S. PINDYCK (1994) *Investment Under Uncertainty* (Princeton: Princeton University Press)
- ECOBILAN (1998) "Eco-Efficiency Trends and Potentials in the Electronics Industry" (Paris: Ecobilan Environmental Consulting, mimeo).
- ENVIRONMENTAL LAW INSTITUTE (1999) 'Innovation, Cost and Environmental Regulation: Perspectives on Business Policy and Legal Factors Affecting the Cost of Compliance' (Washington D.C.: ELI).
- EPSTEIN, M. AND D. YOUNG (1998) 'Improving Corporate Environmental Performance through Economic Value Added' (Fontainebleau, France: INSEAD Centre for the Management of Environmental Resources, Working Paper 98/15/AC)
- EUROPEAN COMMISSION DIRECTORATE-GENERAL FOR ENTERPRISE (2000) *Business, Eco-efficiency and Sustainable Development - the Role of Environmental Business Tools* Report on International Workshop Organised by INETI, Portuguese Directorate-General of Industry and the European Commission, Lisbon, 1-3 March 2000.
- FÄRE, ROLF, SHAWNA GROSSKOPF AND DANIEL TYTECA (1996) 'An Activity Analysis Model of the Environmental Performance of Firms' in *Ecological Economics*, Vol. 18, No. 2, pp. 161-175.
- FIVE WINDS INTERNATIONAL (2000) "The Role of Eco-efficiency: Global Challenges and Opportunities in the 21st Century" (Ottawa: Five Winds International, mimeo)
- FREIMANN, JÜRGEN (2000) 'Environmental Management and Information Systems' in H. Folmer and H. Landis Gabel (eds.) *Principles of Environmental and Resource Economics* (Cheltenham: Edward Elgar)

- GABEL, H. L. AND B. SINCLAIR-DESGAGNÉ (2000) 'Corporate Responses to Environmental Concerns' in H. Folmer and H. Landis Gabel (eds.) *Principles of Environmental and Resource Economics* (Cheltenham: Edward Elgar)
- GABEL, H. L. AND B. SINCLAIR-DESGAGNÉ (1999) 'The Firm, its Procedures, and Win-Win Environmental Regulations' (Fontainebleau, France: INSEAD Centre for the Management of Environmental Resources, Working Paper 99/05/EPS)
- GABEL, H. LANDIS AND B. SINCLAIR-DESGAGNÉ (1993) 'Managerial Incentives and Environmental Compliance' in *Journal of Environmental Economics and Management*, Vol. 24, pp. 229-240.
- GALLOPÍN, GILBERTO CARLOS (1997) "Indicators and Their Use: Information for Decision-Making" in Bedrich Moldan and Suzanne Billharz (eds.) *Sustainability Indicators: Report of the Project on Indicators of Sustainable Development* (Chichester: John Wiley and Sons).
- GARROD, BRIAN AND PETER CHADWICK (1996) 'Environmental Management and Business Strategy: Towards a New Strategic Paradigm' in *Futures*, Vol. 28, No. 1, pp. 37-50.
- GERMAN FEDERAL ENVIRONMENT AGENCY (2000) 'EMAS in Germany: Report on Experience 1995 to 1998' (Berlin: German Environment Agency).
- GERMAN FEDERAL ENVIRONMENT MINISTRY/GERMAN FEDERAL ENVIRONMENT AGENCY (1997) 'A Guide to Corporate Environmental Indicators' (Bonn/Berlin: German Environment Ministry)
- GRAY, WAYNE B. AND MARY E. DEILY (1996) 'Compliance and Enforcement: Air Pollution Regulation in the U.S. Steel Industry' in *Journal of Environmental Economics and Management*, Vol. 31, pp. 96-111.
- GUDMUNDSON, HENRIK and NIELSEN, THOMAS S. (1998) "Reduction of Environmental Pressure Related to Car Transport by Factors 4 and 10" (Copenhagen: Danish National Environmental Research Institute)
- HAMILTON, JAMES T. (1995) "Pollution as News: Media and Stock Market Reactions to the TRI Data" *Journal of Environmental Economics and Management*, Vol. 28, 1995, pp. 98-113.
- HART, STUART L. AND GAUTAM AHUJA (1996) 'Does it Pay to be Green? An Empirical Examination of the Relationship Between Emission Reduction and Firm Performance' *Business Strategy and the Environment*, Vol. 5, pp. 30-37.
- HARTMAN, R, MAINUL HUQ AND DAVID WHEELER (1993) 'Why Paper Mills Clean Up: Results from a Four-Country Survey in Asia' (Washington D.C.: World Bank, Policy Research Department Working Paper no. 1416).
- HEMMELSKEMP, JENS (1999). 'The Influence of Environmental Policy on Innovative Behaviour: An Econometric Study' (Seville: IPTS, mimeo).
- HENRIQUES, IRENE AND PERRY SADORSKY (1996) 'The Determinants of an Environmentally Responsive Firm: An Empirical Approach' in *Journal of Environmental Economics and Management*, Vol. 30, pp. 381-395.

- HETTIGE, HEMAMALA ET AL. (1996) 'Determinants of Pollution Abatement in Developing Countries: Evidence from South and Southeast Asia' in *World Development*, Vol. 24, No. 12, pp. 1891-1904.
- HETTIGE, HEMAMALA ET AL. (1994) 'The Industrial Pollution Projection System' (Washington D.C.: World Bank, Policy Research Working Paper 1431).
- INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (1996), *Technologies, Policies and Measures for Mitigating Climate Change*, R. T. Watson, M. C. Zinyowera and R. H. Moss (eds.), IPCC, Geneva.
- INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (1997) *Standard 14040* Geneva: ISO.
- JAFFE, ADAM B., RICHARD G. NEWELL AND ROBERT N. STAVINS (2000) 'Technological Change and the Environment' (Cambridge, Mass.: NBER Working Paper No. 7970).
- JAGGI, B AND M. FREEDMAN (1992) 'An Examination of the Impact of Pollution Performance on Economic and Market Performance: Pulp and Paper Firms' *Journal of Business Finance and Accounting*, Vo. 19, pp. 697-713.
- JOHNSTONE, NICK (1998) 'Globalisation, Technology and the Environment' in *OECD Globalisation and the Environment* (Paris: OECD)
- KARL, HELMUT AND CARSTEN ORWAT (2000) 'Environmental Marketing and Public Policy' in H. Folmer and H. Landis Gabel (eds.) *Principles of Environmental and Resource Economics* (Cheltenham: Edward Elgar)
- KESTEMONT, MARIE-PAULE AND BJARNE YTTERHUS EDS. (1997). *European Business Environmental Barometer* (Report prepared for EC DGIII, Research Report SUB/97/5005441/UCL)
- KHANNA, MADHU AND LISA A. DAMON (1999) 'EPA's Voluntary 33/50 Program: Impact on Toxic Releases and Economic Performance of Firms' *Journal of Environmental Economics and Management*, Vol. 37, pp. 1-25.
- KLINKERS, LEON, WIM VAN DER DOOY AND HENK WIJNEN (1999) 'Product-Oriented Environmental Management Provides New Opportunities and Directions for Speeding up Environmental Performance' in *GMI*, No. 26, Summer, 1999, pp. 91-106.
- KONAR, SHAMEEK AND MARK A. COHEN (1997) 'Why do Firms Pollute (and reduce) Toxic Emissions' mimeo, Owen Graduate School of Management, Vanderbilt University, Nashville, Tennessee.
- LANOIE, PAUL, BENOÎT LAPLANTE AND MAITÉ ROY (1998) 'Can Capital Markets Create Incentives for Pollution Control' in *Ecological Economics*, Vol. 26, pp. 31-41.
- LAPLANTE, BENOÎT AND PAUL LANOIE (1994) 'The Market Response to Environmental Incidents in Canada: A Theoretical and Empirical Analysis' *Southern Economic Journal*, Vol. 60, No. 3, pp. 657-672.
- LEFEBVRE, LOUIS A., ELISABETH LEFEBVRE AND MARIE-JOSEE ROY (1995) 'Integrating Environmental Issues into Corporate Strategy: A Catalyst for Radical Organizational Innovation'

Montréal: Centre Interuniversitaire de Recherche en Analyses des Organisations, Working Paper No. 95s-24.

LEHNI, MARKUS (1998) 'WBCSD Project on Eco-Efficiency Metrics and Reporting: State of Play Report' Geneva: WBCSD mimeo.

LEVY, DAVID L. (1995) 'The Environmental Practices and Performance of Transnational Corporations' in *Transnational Corporations*, Vol. 4, No. 1, pp. 44-67.

LYON, THOMAS P. and JOHN W. MAXWELL (1999) 'Voluntary Approaches to Environmental Regulation: A Survey' Bloomington, Indiana, Kelley School of Business, mimeo.

MALAMAN, ROBERTO (1996) 'Technological Innovation for Sustainable Development: Generation and Diffusion of Cleaner Technologies in Italian Firms' (Milan: Fondazione Eni Enrico Mattei, Working Paper)

MALONEY, M. T. AND G. L. BRADY (1988). "Capital Turnover and Marketable Pollution Rights". *Journal of Law and Economics*, 31 (April): 203-226.

MARSHALL, ALFRED (1922). *Principles of Economics* (London: Macmillan).

MARTIN, P., D. WHEELER, M. HETTIGE AND R. STENGREN (1991) 'The Industrial Pollution Projection System: Concept, Initial Development and Critical Assessment' Washington, D.C.: World Bank Discussion Paper.

MONASH CENTRE FOR ENVIRONMENTAL MANAGEMENT (1999) 'Survey of Productivity and Environmental Strategies and Practices in Australian Manufacturing Companies' mimeo, Monash Centre for Environmental Management, Graduate School of Environmental Science, Monash University, Clayton, Australia.

MORRISON, CATHERINE (1991) *Managing Environmental Affairs: Corporate Practices in the U.S., Canada and Europe* New York City: Conference Board of New York.

MÜLLER, KASPAR AND ANDREAS STURM (2000) *Standardized Eco-Efficiency Indicators* Basel: Ellipson Management Consultants

NATIONAL ROUND-TABLE ON THE ENVIRONMENT AND THE ECONOMY (1999) *Measuring Eco-Efficiency in Business: Feasibility of a Core Set of Indicators* Ottawa: Renouf Publishing.

NELSON, R. A., T. H. TIETENBERG AND M. R. DONIHUE (1993). "Differential Economic Regulation: Effects on Electric Utility Capital Turnover and Emissions". *Review of Economics and Statistics*, Vol. 85, pp. 368-373.

NELSON, R. AND S. WINTER (1982) *An Evolutionary Theory of Economic Change* (Cambridge, MA: Harvard University Press).

NORTEL NETWORKS/ENVIRONMENT CANADA (2000) "Understanding the Environmental Aspects of Electronic Products: A Life Cycle Assessment Case Study of a Business Telephone" (Ottawa: Nortel, mimeo).

OECD DSTI (2001a) *Encouraging Environmental Management in Industry* (Paris: OECD)

ENV/EPOC/WPNEP(2001)31/FINAL

OECD (2001b) "Draft Programme of Work and Budget on Resource Efficiency, Consumption Patterns and Waste" (OECD ENV/EPOC/WPNEP(2001)3.)

OECD (2001c) "Case Study on Policy Instruments for Environmentally Sustainable Building Policies" (OECD ENV/EPOC/WPNEP(2001)33.)

OECD (2001d) "OECD/IEA Joint Workshop on the Design of Sustainable Building Policies: Synthesis Report" (OECD ENV/EPOC/WPNEP(2001)32.)

OECD (2000a) "Draft Final Report of the Eco-Efficiency Project: The Firm, The Environment and Public Policy" ENV/EPOC/PPC(2000)10.

OECD (2000b) "The Firm and the Environment: Lessons from a Survey of European Manufacturing Firms" ENV/EPOC/PPC(2000)9.

OECD (2000c) 'Background Report for the Business and Industry Policy Forum on Environmental Management: Challenges For Industry' OECD/DSTI/IND(2000)10

OECD (1999A) 'Eco-Efficiency: Completion of WPPPC Project And Report From The Sydney Eco-Efficiency' OECD/ENV/EPOC/PPC(99)1.

OECD ENV (1999B) *Voluntary Approaches for Environmental Policy* (Paris: OECD)

OECD (1998) *Eco-Efficiency* (Paris: OECD)

PALMER, KAREN ET AL. (1995) 'Tightening Environmental Standards: The Benefit-Cost or the No-Cost Paradigm?' in *Journal of Economic Perspectives*, Vol. 9, No. 4, pp. 119-132.

PARGAL, SHEOLI AND DAVID WHEELER (1995) 'Informal Regulation of Industrial Pollution in Developing Countries: Evidence from Indonesia' (Washington D.C.: World Bank, Policy Research Department Working Paper no. 1416).

PERSSON, CECILIA (1999) "Eco-Efficiency: Trends and Potentials for the Food Supply Chain" (Stockholm: Naturvårdsverket, mimeo)

PFAFF, ALEXANDER S.P. AND CHRIS WILLIAM SANCHIRICIO (1999) 'Environmental Self-Auditing: Setting the Proper Incentives for the Discovery and Correction of Environmental Harm' (New York: Columbia University, School of International and Public Affairs, Working Paper No. 4)

PLASTICONSULT (1999) "Eco-Efficiency Trends and Potentials in the Plastics Industry" (Milan: Plasticsconsult, mimeo)

PORTER, MICHAEL E. AND CLAES VAN DER LINDE (1995) 'Toward a New Conception of the Environment-Competitiveness Relationship' in *Journal of Economic Perspectives*, Vol. 9, No. 4, pp. 97-118.

RUSSO, M. V. AND P.A. FOUTS (1997) "A Resource-Based Perspective on Corporate Environmental Performance and Profitability" in *Academy of Management Journal*, Vol. 40, No. 3

SHARMA, S. (2000) "Managerial Interpretation and Organizational Context as Predictors of Corporate Choice of Environmental Strategy" in *Academy of Management Journal*, Vol. 43, pp. 681-702

- SHELTON, ROBERT D. AND JONATHAN B. SHOPLEY (1997) 'Beyond the Green Wall: Rethinking Environmental Management for Business Advantage' in Grant Ledgerwood (ed.) *Greening the Boardroom: Corporate Environmental Governance and Business Sustainability* London: Greenleaf Publishing.
- SINCLAIR-DESGAGNÉ, B. AND H. L. GABEL (1996) 'Environmental Auditing in Management Systems and Public Policy' (Fontainebleau, France: INSEAD Centre for the Management of Environmental Resources, Working Paper 96/41/EPS)
- SINISCALCO, DOMENICO, STEFANIA BORGHINI, MARCELLA FANTINI AND FEDERICA RANGHIERI (2000) 'the Response of Companies to Information-Based Environmental Policies' FEEMI Working Paper, Milan.
- SOCIETY OF ENVIRONMENTAL TOXICOLOGY AND CHEMISTRY (1993) *Guidelines for Life-Cycle Assessment: A 'Code of Practice'* Brussels: SETAC.
- STREITWEISER, MARY L. (1994) 'Cross-Sectional Variation in Toxic Waste Releases from the U.S. Chemical Industry' (Washington D.C.: US Bureau of the Census, Center for Economic Studies, Working Paper 94-8).
- SWEDISH ENVIRONMENTAL PROTECTION AGENCY (2000) *Dematerialisation and Factor 10: A Survey* Stockholm: SEPA, AFR Report 240
- TYTECA, DANIEL (1994) 'On the Measurement of Environmental Performance in Firms – Literature Review and Productive Efficiency Approach' (Washington D.C.: Resources for the Future, Discussion Paper 94-28)
- UNITED NATIONS CONFERENCE ON TRADE AND DEVELOPMENT, Programme on Transnational Corporations (1993) *Environmental Management in Transnational Corporations: Report on the Benchmark Corporate Environmental Survey* (New York: UN)
- UNITED NATIONS ENVIRONMENT PROGRAM (1995) *Cleaner Production Worldwide Volume II*, Paris: UNEP, Industry and Environment Cleaner Production Program.
- UNITED STATES ENVIRONMENTAL PROTECTION AGENCY, Office of Pollution Prevention and Toxics (1998). *Searching for the Profit in Pollution Prevention: Case Studies in the Corporate Evaluation of Environmental Opportunities* (Washington D.C.: EPA 742-R-98-005).
- UNITED STATES OFFICE OF TECHNOLOGY ASSESSMENT (1994) *Industry, Technology and the Environment: Competitive Challenges and Business Opportunities* (Washington D.C.: OTA, 1994).
- VAN BERKEL, RENÉ, MICHAELA VAN KAMPEN AND JAAP KORTMAN (1999) 'Opportunities and Constraints for Product-Oriented Environmental Management Systems' *Journal of Cleaner Production*, Vol. 7, pp. 447-455.
- WELFORD, RICHARD (1999) *Corporate Environmental Management* (London: Earthscan, 1999)
- WHEELER, DAVID AND PAUL MARTIN (1992). 'Prices, Policies and the International Diffusion of Clean Technology: The Case of Wood Pulp Production' in P. Low (ed.) *International Trade and the Environment*, Discussion Paper No. 159 (Washington: World Bank), pp.197-224

WORLD BANK (1998) 'The Guadalajara Environmental Management Pilot Project' World Bank, NIPR Project Report No. 18071-ME.

WORLD BUSINESS COUNCIL FOR SUSTAINABLE DEVELOPMENT (1993), *Getting Eco-Efficient*, Report of the Business Council for Sustainable Development, First Antwerp Eco-Efficiency Workshop, November 1993, BCSD, Geneva.

WORLD BUSINESS COUNCIL FOR SUSTAINABLE DEVELOPMENT (1995), *Achieving Eco-Efficiency in Business*, Report of the World Business Council for Sustainable Development, Second Antwerp Eco-Efficiency Workshop, 14-15 March, WBCSD, Geneva.

WORLD RESOURCES INSTITUTE (2000a) *The Weight of Nations: Material Outflows from Industrial Economies* (Washington, D.C.: WRI)

WORLD RESOURCES INSTITUTE (2000b) *Pure Profit: The Financial Implications of Environmental Performance* (Washington, D.C.: WRI).

WORLD RESOURCES INSTITUTE. (1997). *Resource Flows: The Material Basis of Industrial Economies*. Washington, D.C.: WRI.