Environmental RTDI Programme 2000 – 2006

Sustainable Development – Environmental Technology, Dynamic Environmental Capabilities and Competitiveness (2004-SD-T1-v)

Synthesis Report

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Prepared for the Environmental Protection Agency

by

Centre for Innovation & Structural Change, National University of Ireland, Galway

Authors:

Dr. Rachel Hilliard, Professor Donald Goldstein and Valerie Parker

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The EPA ERTDI Programme addresses the need for research in Ireland to inform policymakers and other stakeholders on a range of questions in relation to environmental protection. These reports are intended as contributions to the necessary debate on the protection of the environment.

ENVIRONMENTAL PROTECTION AGENCY

An Ghníomhaireacht um Chaomhú Comhshaoil

PO Box 3000, Johnstown Castle, County Wexford, Ireland

Telephone: +353 53 916 0600 Fax +353 53 916 0699

Email: info@epa.ie Website: http://www.epa.ie/

Executive Summary

The project was funded during 2005-2008, through the Centre for Innovation and Structural Change (CISC) at National University of Ireland, Galway. The goal was to develop new analytical tools for modelling the environmental and economic performance of companies in Irish industry; test those tools using statistical, survey, and case study analysis of firms across industry sectors; and infer policy measures with potential for encouraging sustainable business development. A key focus was whether organisational 'static and dynamic environmental capabilities' could help explain differential adaptation by companies to licensing. Firms studied are those covered by EPA's Integrated Pollution Control (IPC) licensing programme, beginning in 1996 near its inception and through its end in 2004. Specific goals included:

To develop an integrated database on environmental performance, management and technology, and financial performance, among firms across industrial sectors. Sectors were chosen for number of facilities, preponderance of firms with their own accounts, lack of intra-firm trade that could bias financial data, and range of environmental aspects and approaches: metal fabricating, paint and ink manufacturing, and wood products and preservation. Financial data are from the Companies Records Office; environmental data come primarily from license applications, Annual Environmental Reports, and correspondence on file with EPA.

To develop indicators of:

***Environmental performance*.** Three sets were created: an index of '*key emissions'*, frequently reported pollutants important in each sector; for *waste*, total tonnes, percent hazardous, and percent disposed; and in *resource use,* electricity, fuel, water, and a composite indicator. Mass data is normalised by employment for comparability over time and companies, and the indicators are expressed as ratios with sector averages to permit cross-sector comparability.

Environmental management. Hundreds of projects were scored and used to create annual measures of procedural, planning, and training related management practice, and a composite.

Environmental technology. Hundreds more projects were used to create annual technology indicators categorised both by pollution prevention approach and stage in the production process. Each project is scored according to how widespread its use in the facility and sector-specific criteria on how clean the technology, with comparability ensured by uniform approach and stage categories for all three sectors.

To develop indicators of organisational capabilities that may complement the effect of management and technology practices on environmental performance. An indicator of 'static capability' was developed based on 'learning by doing' research, as a function of experience with particular kinds of practice measured by number of projects and elapsed time. 'Dynamic capability' was operationalized using activities involving information search and processing, internally within the firm and externally from outside sources. EPA data is supplemented with responses to a mailed-out survey.

To develop statistical models of the relationships between environmental performance, economic performance, environmental technology and management practices, and organisational capabilities. Nonparametric partial correlation is used, appropriate to a small sample with many extreme values and non-normal distributions, and to control for interrelationships among variables. Higher levels of environmental practice are associated with reduced key emissions. For waste and resource use, reverse causality characterises the relationship with technology practice: heavier impacts stimulated greater practice. Static capability generally plays a mediating role in technology, and shows the importance of experience gained prior to IPC licensing; little support for the role of dynamic capability is found. Finally, economic performance measured as operating efficiency is enhanced by environmental technology practice*.* There is little evidence that environmental effort impedes economic results.

To develop a more nuanced understanding, through qualitative research, of the processes and dynamics at work within the broad statistical contours. Case interviews reveal the importance of higher order management practice, including integrative processes of planning, wide searches for information, cross-functional problem solving, and team-based activity. Doing this internally rather than via consultants facilitates more change, and combining these organisational activities with technology upgrades is also important. Several expressed the view that EPA could be more helpful with a shift toward advice and assistance rather than (in their view) simply enforcement.

To develop recommendations on effective policy interventions in the regulation of the environmental impact of industrial activity. The efficacy of the IPC licensing system is supported by downward trends in the environmental impact indicators over the time period studied. That, and the role of early experience in generating accumulation of capabilities, suggest the importance of getting facilities into the programme as quickly as possible. Effectiveness could be enhanced by greater standardisation of monitoring and reporting requirements across similar facilities, lessening the burden on EPA staff, increasing perceived fairness among regulated companies, and facilitating outcomes assessment. Finally, developing EPA's role in providing expert assistance to licensees would strengthen the dissemination of best practices while improving relations with key stakeholders.

1 Introduction

The *Dynamic Environmental Capabilities* research project was conducted over three years from 2005-2008 at the Centre for Innovation and Structural Change (CISC) at National University of Ireland, Galway.

The goal of the project was to develop new analytical tools for modelling the environmental and economic performance of companies in Irish industry; test those tools using statistical, survey, and case study analysis of companies across industry sectors; and infer policy measures with potential for encouraging business development along a sustainable path.

Companies studied are those covered by the EPA's Integrated Pollution Control (IPC) licensing programme. Companies' licensing applications and Annual Environmental Reports (AERs) under the IPC programme represent a rich source of data on the organisational and technological aspects of environmental decision-making (EPA, 1997). The project combines this EPA data with business data from the Companies Registration Office (CRO) for integrated modelling of environmental and economic performance and their interaction.

The project contributes to the development of Irish sustainable development policy by developing and testing a set of analytical tools for understanding environmental and economic performance of industry, how they are linked and how they can be improved. The research thus aimed to foster the integration of the concerns of environmental and industrial/innovation policies.

The questions we are interested in answering are:

What are the determinants of cleaner production?

What is the relationship between environmental performance and competitiveness?

What policy implications arise from application of these analytical tools?

We study the sources of environmental and economic performance in the context of particular industry sectors.

- Metal fabricating;
- Paint and ink manufacturing; and
- Wood sawmilling and preservation.

Companies in different sectors have different ranges of technology, environmental concerns, and supply chain and market demand considerations related to environmentally relevant process and product decisions. The companies selected give us a range of sophistication in production processes, from relatively simple (wood) to complex (paint). Environmental concerns across the sectors involve different media (air emissions from VOCs in metal and paint, and diverse water emissions for all three) and levels of hazard. Most are industries where niche demand for more environmentally friendly products has appeared in some markets (paint and wood). Of key practical importance, the EPA's files contain enough members of each sector to permit meaningful comparison, basic statistical analysis, and anonymity for the companies.

Data construction involves gathering raw information and using it to construct variables for analysis. Both steps – what to look for, and how to put it together – are guided by the research questions that the project seeks to answer. We are interested in what distinguishes the companies that were able to meet the challenges of the Irish EPA's IPC licensing effectively in environmental terms and competitively in economic terms. This central research interest suggests that we test the relationships among the following:

- Companies' *environmental practices*;
- The *environmental performance* associated with those responses;
- The *economic performance* coincident with the above; and
- *Organisational capabilities* that we hypothesise may act as complements, by mediating the relationship between the environmental responses and the environmental and economic outcomes.

Sources of information include the following:

- Records and reports submitted by licensed companies to the EPA – initial licensing applications, Annual Environmental Reports (AERs), and correspondence;
- Financial records collected by the Companies Registration Office (CRO);
- Survey sample companies that collected additional information about the processes and sources of environmental decision making; and
- Interviews with environmental managers in a selected sample of case study companies.

Systematic investigation of the relationships between environmental and economic performance in business is high on current research and policy agendas in order that the EU imperatives of growth and environmental quality might be bridged (Joint Research Centre, 2004). Much of the prior research and debate on these relationships has centred on the 'Porter hypothesis' (Porter, 1991; Porter and van der Linde, 1995). The argument is that well designed tightening of environmental regulation might not impose costs on industry on balance, due to cost offsets from induced technology innovation and diffusion.

Empirical research on this question has generated mixed results, 'a case of a "partially full glass" that analysts see as mostly full or mostly empty, depending on their perspective' (Jaffe *et al*., 2000, p. 30). Much of the research suffers from lack of a coherent theory of how firm-level innovation and diffusion occur (Hilliard, 2004), especially of we want to explain the observed fact that not all companies respond to regulation with innovation. A useful framework within which to approach the problem is provided by evolutionary economics (Nelson and Winter, 1982). Facing highly uncertain alternatives, and lacking the ability to process even a significant portion of the available information but needing to act nonetheless, managers focus their attention on tested ways of deciding what is 'good enough', which in turn reflect the evolution over time of routines based in (often tacit) organisational knowledge. Like a living organism's genes, these routines define a set of ‘organisational capabilities’ for responding to the challenges of the competitive environment (Chandler, 1992). Because companies evolve differently, they exhibit different kinds of organisational capabilities that condition them to behave in different ways.

Managerial and technological capabilities based in an era of cheap energy and unregulated environmental impacts might be seen as retarding the emergence of cleaner but still profitable innovations, and dampening the recognition and diffusion of those that already exist. Behaviour changes and performance improves when tightened regulation (Hilliard, 2002) or changed corporate priorities (Goldstein, 2002) induce a shift in managerial focus, so that options that were previously not very far out of sight come into view. Capability theory provides a powerful set of tools for analysing the processes of technical and organisational change. Research suggests that variation in companies’ environmental performance may be driven by differential organisational capabilities in combining related skills, technologies, and work processes regarding environmental management and technologies (Hilliard, 2002).

Several prior studies have assessed in particular the outcomes surrounding IPC licensing: Cunningham (2000), Clinch and Kerins (2002), Duffy et al. (2003), and Karavanas et al., who examine IPC’s successor, the IPPC framework (2009). The present project takes up these important issues using current research within the broad evolutionary literature on the economics of management and the firm, in order to illuminate the corporate-level mechanisms and processes suggested by the induced innovation hypotheses regarding environmental regulation.

In our research, we focus on three key questions arising from the theoretical organisational capabilities literatures:

- Can we identify static organisational (technology and management) capabilities that enable companies to perform effectively?
- If so, over what kind of time frame are such capabilities subject to purposeful change through decision processes that assess and implement new ways of doing things?
- And finally, can we locate dynamic capabilities that allow companies to adopt new static capabilities?

2 Measuring Environmental Performance, Practice, and Capabilities

We introduce rubrics for defining major dimensions of environmental performance, and the management and technology practices that might affect performance, in which the variables can be scored according to sector-specific criteria and these scores compared across sectors. Organisational capability measures are then constructed based on experience with the corresponding practices so defined. This innovative methodology is of further interest because it uses IPC information generated EU-wide and is thus capable of cross-country extension.

2.1 *Measuring environmental performance*

2.1.1 Key emissions

The EPA indicates which emissions are of greatest concern for each license holder when it specifies which must be monitored and reported: for air, sewer (effluent), and surface water discharges. Other industry sources have been used as well in determining here which emissions are key in each sector. They are VOCs to air, and pH, COD, zinc, and suspended solids to water, for both metal fabricating and paint and ink manufacturing; and pH, COD, suspended solids, copper, chromium, and arsenic to water for wood sawmilling and preservation. We make 7.5 the centre of an acceptable pH range and take the absolute value of the difference between 7.5 and measured pH, with higher values indicating worse performance.

The emissions data used is measured in mass amounts of kg/year. In order for this to be meaningfully comparable over time and across firms, next we normalise each reported emission (and the waste and resource use measures discussed below) relative to a standard unit of production scale. Because output data is not available for our sample, we use number of employees as a proxy.[1] Once normalised, we calculate each annual facility emission value as a ratio with its sector average.[2] When expressed this way, above versus below sector average facilities can be compared across sectors although the specific emissions in each sector may be different.

Finally, we compute each facility's key emissions value for each year as a simple average of the individual emission amounts reported in that year, each normalised (if a mass value) and expressed as a ratio with sector-average. This approach uses all available data on what EPA and other authorities consider important. Its disadvantage is that we compare companies using a measure whose components are not uniform across all firms.

2.1.2 Waste

Waste categories are standardised internationally via the Pollution Emissions Register (PER) reports. Waste is classified as either 'hazardous' or 'non-hazardous', and its ultimate handling is classified as involving 'recovery' via some kind of treatment and reuse, versus 'disposal' to the environment (e.g., via incineration or land filling). Combinations of these have been used to create three waste variables, each expressed as ratios with their respective sector averages: Total waste (normalised by employment), percentage of total waste that is disposed, and percentage of total waste that is hazardous (no normalisation required for the latter two).

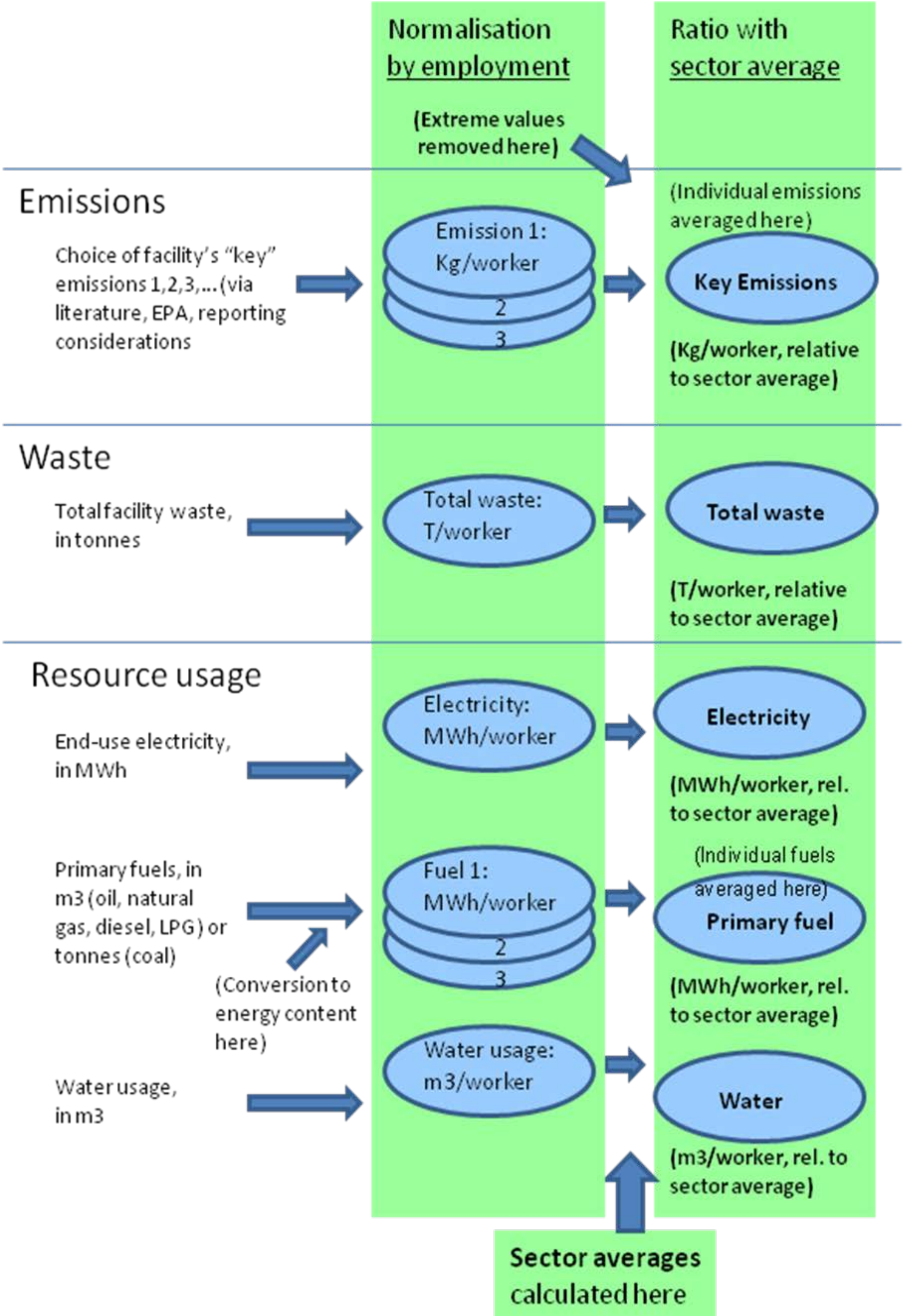
2.1.3 Resource Usage

[1] There is a potential bias in normalising this way, as greater technology over time and/or firms might increase productivity. If output per worker rises, then all else equal, so will mass emissions. With mass emissions in the numerator and employment in the denominator, then, the measure may be biased upward for higher values of technology. Our hypothesis is that greater technology will reduce (normalised) emissions. Thus the measure tilts the scales against accepting our hypothesis.

[2] Data integrity is guarded at this point by removing extreme normalised values, using 'outer fence' values derived from inter-quartile range analysis, and then requiring that sector averages in each variable contain data from at least three companies.

Licensed facilities report the annual use of electricity, fuel, and water in the AERs. We construct a variable for each, again normalised relative to employment for comparability purposes, and expressed as a ratio to the relevant sector average for cross-sector analysis. We also create a composite measure, the sum of the normalised, sector-averaged values for electricity, fuel, and water.

Figure S2.1 Environmental Performance Variables Construction



2.2 Measuring environmental practice

2.2.1 Management

Planning relates to information search and processing to evaluate possible courses of action. We use information on planning projects from the AER Environmental Management Plans (EMPs) and the correspondence files, scored by the concreteness of goals; use of relevant data to factor past experience into decision making; and evidence of follow through.

Training programs for employees may affect environmental performance by disseminating information about environmental impacts, technologies, and/or management systems. We score training 'projects' according to their concreteness and the extent to which they appear to drive changes in employee behaviour.

Procedures involve tracking, recording, and reporting. One component is an AER score based on the timeliness and completeness with which reporting requirements are met. Another component is EPA non-compliance notifications of a procedural (rather than pollution-oriented) nature. We again use a severity-weighted sum of the year's procedural non-compliances. The facility-year value for the management procedural variable is the sum of these AER and procedural non-compliance scores.

Table S2.1 shows that by two of three individual indicators and their composite, the paint and ink manufacturing facilities appear by these measures to exhibit a higher level of management practice.

Table S2.1 Sector Averages: Management Practice

	Metals	Paints	Woods
Procedures	-3.24	-1.20	-1.68
Planning	3.72	3.20	2.45
Training & Development	1.28	1.85	0.51
Composite (Sum)	*2.28*	*5.00*	*2.54*

2.2.2 Technology

The license applications, AERs, and correspondence files contain information about technology 'projects': changes in the inputs, processes, and/or equipment by which outputs are created. The first step in going from technology projects to practice variables is facilitating cross-sector analysis while capturing sector-specific characteristics, by locating the projects within a cross-sector technology matrix. One dimension categorises projects according to pollution-prevention approaches, and the other according to stages in the production process. The pollution-prevention and stages of production categories are common across sectors, while projects are assigned to both using criteria specifically defined for each sector.

The categories in the pollution-prevention dimension of the matrix are raw materials substitution; closing the loop to permit reuse of waste, product, or by-product; equipment changes; and other process changes. The stages-of-production categories are product design, preparation, basic production, finish work, and housekeeping/other – specified as follows for each sector. Metal fabricating: product design (especially choice of finish coating); metal shaping; surface preparation; surface finish; and housekeeping/other (storage, cleaning, bunding, waste handling, packaging, etc.). Paints and inks: formulation; dry milling and mixing; wet milling and mixing; filtering and filling; and housekeeping/other. Wood sawmilling and preservation: product design (choice of pressure treatment chemical, lumber sourcing); conditioning and cutting; pressure treatment; storage and drip; and housekeeping/other.

Each project is assigned to the appropriate cell in the technology matrix for that facility-year, then scored 1-5, depending on its nature and scope: 1 = End-of-pipe, small scope relative to the facility; 2 = End-of-pipe, medium to wide scope; 3 = Clean technology, less fundamental to production process and/or small scope; 4 = Clean technology, medium role in process and/or scope; and 5 = Clean technology, more fundamental and/or wide scope. Clean technology prevents or reduces environmental impact at the source, while end-of-pipe controls a given impact once created. All project scores in each facility-year matrix cell are added together. These cells have been combined to create technology practice aggregates in each production stage and pollution prevention approach, and also a composite of all technology projects.

The second step in going from technology projects to practice variables is recognising the ongoing effects of technology once implemented. These effects decrease over time, with depreciation and reduced fit between projects and the surrounding production systems. We transform the summed projects from the technology matrix cells into technology practice variables assuming five year project lifetimes (Doms 1992). Each project's score enters the variable at half its value in its first year (due to start-up lags), full value the second, then 75, 50, and 25 percent of the original value in project years three, four, and five. Table S3.2 shows the sector averages. Like in management, the paints sector scores higher here in key respects.

Table S2.2 Sector Averages: Technology Practice

		Metals	Paints	Woods
Approaches	Raw materials substitution	3.50	2.40	1.67
	Closing the loop	2.41	4.33	2.59
	Equipment investment	4.75	6.20	5.55
	Process change NEC	2.60	2.05	3.04
Stages	Product design	0.46	2.06	1.59
	Preparation	2.87	1.59	3.62
	Basic production	2.06	3.70	3.99
	Finish work	4.05	0.64	1.42
	Housekeeping/other	4.03	6.99	2.17
	Composite (Sum)	*13.26*	*14.98*	*12.85*

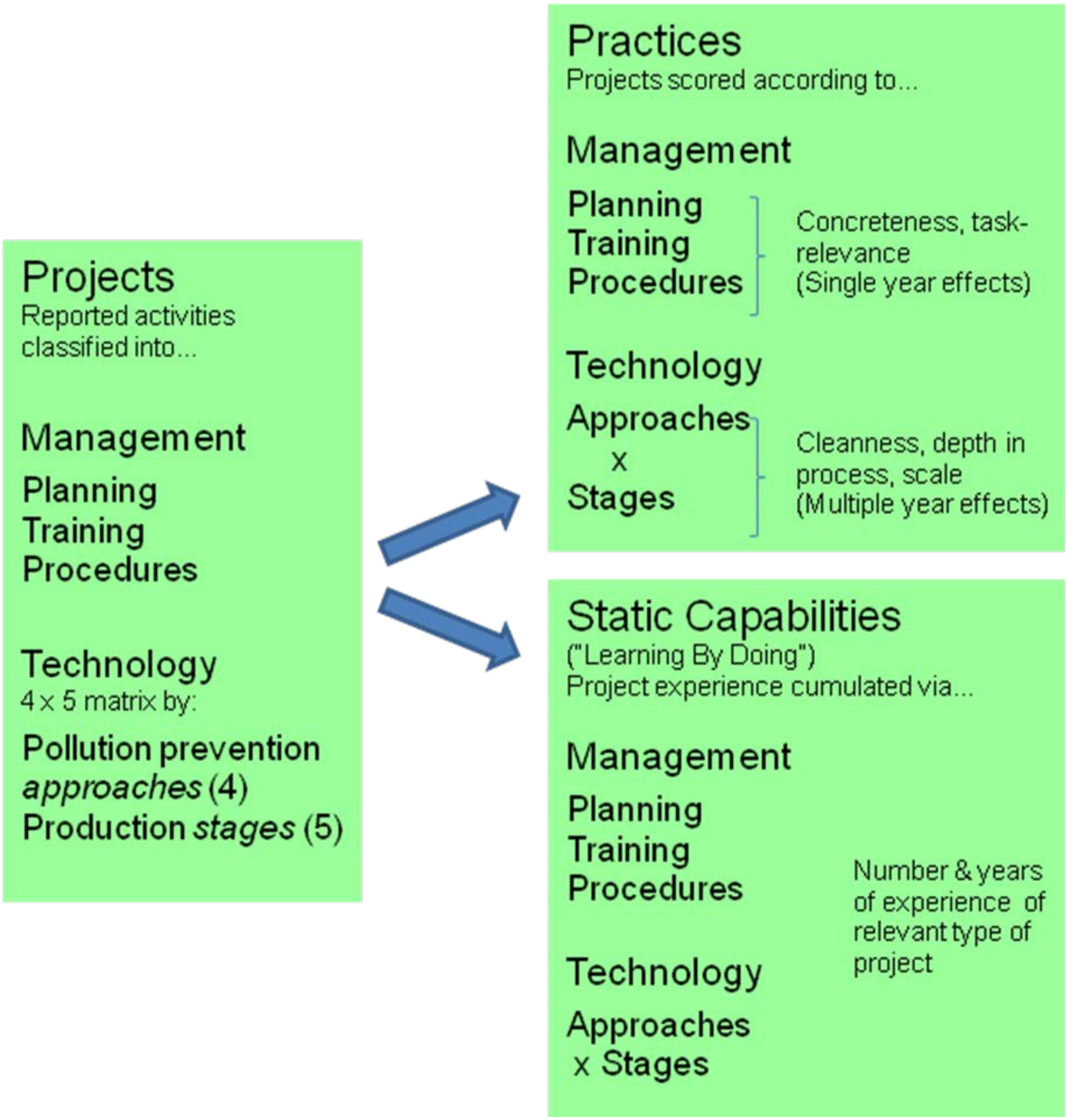
2.3 Measuring organisational capabilities

As noted in Chapter 2, we follow Sharma and Vredenburg (1998) by inferring capability from observed activities. We distinguish capabilities that complement the efficacy of particular kinds of practices ('static') from specialised capabilities enabling firms to learn new ways of doing things ('dynamic').

2.3.1 Static capabilities

We hypothesise that firms build static capabilities through accumulated experience, or learning-by-doing (LBD). We quantify this via the annual technology and management practice variables. The LBD literature suggests that learning occurs through cumulative production with a technology or output, resulting in decreased unit labour time (Argote and Epple, 1990). Rather than cumulative production, we proxy for experience via elapsed time since the appearance of the first project of a given type, and the number of projects implemented. We adapt the idea that learning occurs with respect to experience with *particular kinds* of technology (Klenow 1998) by using our technology and management practices variables to isolate specific kinds of experience. Rather than unit labour time, the variable thought to be enhanced by LBD here is environmental performance. We do not use observed successful outcomes to (falsely) infer the presence of an unobserved capability theorised as leading to the outcome; LBD as we define it is measured independently of environmental performance.

Figure S2.3 Practice and Static Capability Variables Construction



2.3.2 Dynamic capabilities

Our theoretical framework suggests that organisational learning disparities among firms may reflect differential dynamic capabilities: locating, processing, and utilising information in creating static capability. These learning processes occur through organisational integration (Grant, 1996): both *internally* within the firm, and *externally* between the firm and sources in its environment. Since theory suggests that dynamic capability is more or less fixed while it acts upon changing static capabilities, and our data on firms' dynamic capability does not consistently correspond to particular years, we define dynamic capability as characteristics that do not vary with time.

Internal integration might involve the management training and planning practices introduced above, by facilitating the ability to search for and usefully integrate new information. It might also occur through work practices like cross functionality and team production, which appear occasionally in facilities' EPA files. We score training, planning, and work practice projects according to the concreteness of their goals and the extent to which they are driving change. The sum of scores for these activities in a given year becomes a facility-year value for internal dynamic capability, and these annual values are averaged across years for the facility's EPA-based internal dynamic capability variable. We also create an internal integration variable from responses to our mailed-out survey, using the questions on number of key company personnel involved in environmental management; percent of workforce receiving environmental training; frequency of team problem solving; and frequency of interdepartmental cooperation.

External integration is dynamic capability operating through knowledge-creating information flows linking the firm and its outside environment. The variable is constructed from survey data only, because the EPA files do not contain information that is relevant here. External dynamic capability is constructed from scored survey responses on the number of key outside parties (customers, vendors, and others) involved in environmental management; integration of vendors in managing new environmental technology; number of information sources on environmental issues; participation in stakeholder initiatives; membership in professional associations; number and longevity of formal certifications (ISO9000, ISO14000, EMAS).

Table S2.3 shows the sector averages. The wood products facilities lag the others in all three variables, while metals and paints appear to differ mainly with respect to the survey-based internal integration variable. It should be kept in mind that only 16 firms responded to the survey, and we have not attempted to test the representativeness of that group. The EPA-based internal integration variable, in contrast, incorporates data from the full sample of IPC licensed firms in these three sectors. For that variable, as for the management and technology practice variables tabulated above, the paints facilities show the highest average.

Table S2.3 Sector Averages: Dynamic Capability

	Metals	Paints	Woods
Internal integration – EPA data	5.59	6.18	3.14
Internal integration – survey data	20.75	17.22	14.73
External integration – survey data	8.08	8.79	5.80

3 Findings - Environmental Performance, Practice, and Capabilities

3.1 Contemporaneous determinants of environmental performance

In this section we examine whether various measures of annual environmental performance are significantly affected by practices, both management and technology, implemented year to year. Our analytical technique is nonparametric partial correlation using the Spearman's rank-order correlation coefficient.[3] Thus in looking at the correlation between each two target variables, we control for (hold constant, or remove) the effect of other variables whose correlation with each of the targets may confuse the results. We control for the year in all tests, since many of the variables exhibit time trends that may or may not be related to our interests.

3.1.1 Cross-sectoral relationships

We begin by examining the relationship between composite management and technology practices and the performance variables: key emissions, total waste, and combined resource use (Table 4.1 in the full report). Higher values of both management and technology practice are, as expected, associated with reduced emissions, at or near standard levels of statistical significance. But unexpectedly, there is positive correlation between technology and both total waste and combined resource use.

Next we disaggregate the practice variables, starting with each management category vs each environmental impact. Each partial correlation of a management category controls for other management categories and for the aggregate technology variable, and vice versa. The results (Table 4.2) show that the negative relationship between emissions and combined management categories is driven by procedural and planning related management activities. Training related management practice shows more unexpected positive correlation with emissions and total waste.

Disaggregated technology practices – by pollution prevention approach, and by stage in the production process – have been similarly correlated with each impact type, with corresponding partial controls (Tables 4.3 and 4.4). The results show the following:

- Emissions are negatively associated with the loop closing and 'other process' approaches and with the preparation (second) and housekeeping (fifth) stages.
- The equipment approach and the core production (third) stage are positively correlated with all impact types.
- Resource use is positively correlated with all approaches and production stages.

These unexpected associations between higher levels of environmental practices and impacts may be consistent with a reverse-causality scenario, concentrated in certain types of technology investment. Facilities with elevated waste, for example, may attempt to address the problem by

[3] We have chosen nonparametric statistical techniques because the data is not even approximately normally distributed, there are many extreme values, and we cannot always attribute meaningfully uniform intervals to the values arising from the data construction methods used. Hence we are more comfortable with analytical techniques based on rank-ordering.

means of equipment changes, especially at the core production stage.[4] We explore this possibility in three steps.

First, if this is what is driving the contemporaneous relationship, then the positive correlations may disappear if we match early investments with environmental impacts later on. We define the years 1996-2000 as ‘early,’ and 2001-2004 as ‘late,’ averaging all values within these sub-periods, giving each facility a single early value and a single late value for each variable. (We use technology projects rather than practices, since the cumulative impacts built into the latter prevent clean time-period separations.) Then partial correlations are examined between early practices and impacts, early practices and late impacts, and late practices and impacts. Unfortunately, this strategy severely limits the numbers of observations. The limited results (Table 4.5) are not in the main inconsistent with the reverse-causality story with the late impact – late technology correlation positive as it is in the full panel reported earlier, while the relationship disappears when considering early practice and late impact.

The second tack goes back to the full annualised data set, examining the relationship between environmental impacts and successively shorter lags in organisational practice. We focus on technology and its relationships with waste and resource usage, because it becomes increasingly clear that this is where the possibility of the reverse-causality scenario is strongest. The results (Table 4.6) show that as we correlate resource impacts with practices further and further back in time, the strength of the positive association progressively recedes, suggesting that something like the reverse-causality scenario may be going on. On the other hand, the pattern in the technology-waste correlations is not so clear.

None of these tests offer evidence that technology investments pay off later in reduced impacts. But if high-investment facilities start with high environmental impact levels, later improvements may not be sufficient to create negative correlations between early investment and later impacts. Our third strategy explores this, again for total waste and resource usage, by looking at the correlation between technology practice and percent change in the impact variables from that year to the next. Most of the earlier-reported positive associations between technology and environmental impact levels become weakly negative correlations when considering instead percent changes in environmental impact (Table 4.7). Especially for the housekeeping stage, and using new equipment as the approach, there may be a negative relationship with year-on-year changes in environmental impact, as managers and regulators would hope. Together with the other results, these are not inconsistent with the idea that a reverse causality scenario may have been at work.

It is also possible that the positive practice-impact correlations, where they appear, reflect a different set of dynamics.[5] We noted above the potential upward bias in our environmental impact measures as normalised by employment. If larger and/or more profitable firms are more productive, better able to afford costly equipment upgrades and training programs, and also more

[4] Managers may also turn to staff training programs as suggested by Table 4.2.

[5] We thank an anonymous reviewer for the EPA for pointing out this possibility.

likely to exhibit upward-biased impact data, then the observed positive correlation could result. We consider this explanation in the context of analysing differences across the sectors.

3.1.2 Sector-specific relationships

To examine whether the dynamics differ by sector, we again start with the composite practice variables and then disaggregate. For the correlations between environmental impacts and combined technology and management practices, the following patterns emerge (Table 4.8):

- In metal fabrication, technology may weakly correlate with lower key emissions but shows a strong association with higher levels of resource use; management may weakly correlate with lower resource use.
- In paint and ink manufacturing, both practices are negatively correlated with key emissions, although the technology association is not statistically significant; but there are no correlations of either practice with waste or resource use.
- In wood products, management is negatively correlated with waste, though weakly; but technology is positively associated, at statistically significant levels, for waste and resource use.

The positive technology-environmental impact puzzle shows up most strongly in the wood products sector, only partially in metal fabricating, and not at all in paint and ink. On the other hand, the generally negative full-sample association between combined management categories and the environmental impact variables is distributed widely, although inconsistently, across the three sectors. Lower emissions are significantly related to higher management scores for paint and ink facilities, but not for metals. Since paints facilities are on average more profitable and have higher levels of practice than their counterparts in metals and woods, these results do not seem to fit with the productivity-bias explanation of the unexpected positive correlations.

Turning to partial correlations for individual management practice categories by sector (Table 4.9), procedural management is associated with lower impacts in emissions for the metals sector and in waste for wood products. Planning is associated with lower impacts in resource use for metals and in emissions for paint and ink. On the other hand, training and development correlates positively with emissions levels in the metals sector, and (perhaps) positively just below standard significance levels with total waste in metals and wood products; but for the paint and ink facilities, training is associated with lower waste levels. In general, it appears that management practices more consistently exhibit intended outcomes in the paint and ink sector than in the other two.

In partial correlations between impact types and technology approaches and stages (Tables 4.10 and 4.11), signs of reverse-causality positive impact correlations are absent for the paints sector, but again show up in several of the metals and wood products correlations. The cross-sectoral positive correlation between equipment investment and environmental impact is shown here to be driven by facilities in the metals and wood products sectors. Beyond that, no clear patterns stand out. Paint and ink facilities using raw material substitution – which most frequently indicates substituting water for solvent based inputs – have reduced waste. Metals facilities with lots of miscellaneous process changes have done likewise with emissions. But the paint sector exhibits an association between higher waste and more loop closing projects – generally representing reuse of (formerly) waste materials and/or product in subsequent rounds of production. Reverse causality may be at work, but the numbers of observations are insufficient to explore this using techniques like those reported above for the more aggregated data.

The data appear to suggest that the environmental effects of organisational choices in management and technology, made at these facilities in the context of IPC licensing, are highly context specific. At the level of aggregated sectors and management and technology practices, higher levels of practice are linked with improved performance with respect to the emissions that are key for these facilities. At the sectoral level, this holds at accepted significance standards only for management practices in the paint and ink sector. Paints facilities exhibit this strong relationship with reduced emissions for greater managerial effort in both procedures and planning. The puzzling association of greater technology practice with more waste and resource impact seems likely to reflect a reverse-causality process, whereby environmental impact problems stimulate increased activity aimed at reducing those impacts; this seems especially true for equipment investments in the metals and woods sectors and practice in the core production stages across sectors. (It is noteworthy that equipment investment is not associated with reduced impact in any environmental category, sector, or time structure.) Finally, there may be indications that changing the composition of products and/or materials is better able to reduce environmental impacts than other technology changes that take those as given.

3.2 Mediating effects of organisational capabilities

In this section, we examine whether the practice-performance relationship is mediated by organisational capabilities: first, static capabilities that are learned over time, and then dynamic capability to be a good learner. Because the previous section reports that waste and resource usage generally show positive correlations with practice, in ways that are not fully understood, we avoid this complication by focusing our tests on the key emissions performance measure.

Our goals are to shed light on the following questions:

First, does static capability accumulate through practice within the time period of our panel? We would like to know if the kinds of purposeful activities implemented by sample firms generate a learning by doing (LBD) effect, as differential levels of experience across firms and over time improve performance and make given practices more effective in improving environmental performance. The maximum time in the panel is nine years, so we will be testing whether static capability and this mediating effect on the practice-performance relationship can develop that quickly.[6]

[6] We are also, unavoidably, testing jointly the appropriateness of our learning by doing-based model of static capability and its significance so defined in mediating the practice-performance relationship. If standard statistical tests show ‘significance,’ then assuming we have defined capability appropriately, we have learned it is important in this setting. If standard significance tests fail, then either our hypothesis about learning by doing is wrong, or we have proxied it wrong, or both.

Hypothesis 1: Static capability will be negatively associated with emissions, controlling for the effect of the corresponding kind of practice.

Hypothesis 2: Practice will be *less* negatively correlated with emissions when controlling for the effect of the corresponding static capability. I.e., we hypothesise that some of the apparent impact of practice reflects a complementarity effect due to static capability.

Next, does dynamic capability facilitate adaptation to the heightened environmental standards ushered in by IPC licensing? Dynamic capability should improve learning, and firms that are better learners should be more successful in implementing management and technology changes that improve environmental performance. Thus we want to test whether companies with stronger dynamic capabilities responded more effectively to the demands of IPC licensing by building new static capabilities for particular kinds of environmental impact reduction.

Hypothesis 3: The relationships suggested in Hypothesis 1 will be stronger among the higher dynamic capability firms.

3.2.1 Learning by doing: Static capabilities

We would like to know if the kinds of purposeful activities implemented by sample firms generate a learning by doing effect that makes given practices more effective in improving environmental performance. We will be testing whether static capability can develop within the (maximum) nine year time horizon in our panel. In Chapter 3, we defined the static capability variables as functions of the *time* following first implementation of a given type of project, and the *number* of like projects subsequently implemented. We hypothesise that practice and static capability in interaction will be associated with reduced emissions, and that each independently will play such a role.

We start by specifying the complementary effect of capability on the performance-practice relationship in terms of a multiplicative interaction variable. For a given firm and year, we multiply the value of the technology or management practice variable of interest by the value of the corresponding learning-by-doing (LBD) static capability variable. The expected correlation between emissions and these interaction variables is negative: Given some level of practice, we expect a higher level of LBD static capability to reduce emissions; and given some level of LBD static capability, we expect a higher level of practice to reduce emissions.

The two kinds of practice and capability tested here are management combined and technology combined. Due to the substantial cross correlations, we test here the partial correlations of emissions with the technology practice-capability interaction variable, controlling for the effects of management practice and capability; and of emissions with the management practice-capability interaction variable, controlling for the effects of technology practice and capability. To address concerns in the research literature with the relative importance of capability inherited from the past vs that which is subject to purposeful direction in the present, we calculate the LBD static capability variables both excluding and including pre-IPC activities, as reported in firms' license application files. Neither technology nor management capability calculated without pre-IPC experience affects emissions performance. But the data are consistent with Hypothesis 1 for technology LBD capability incorporating both IPC and pre-IPC experience.

Our basic strategy in testing Hypothesis 2 is to model static organisational capabilities as *complements* to the effect of direct practices upon performance. This approach has been applied to environmental impact-reduction by Christmann (2000) and to the efficacy of information technology investment by Brynjolfsson and Hitt (2000). We begin by specifying the complementarity in terms of a multiplicative interaction variable. For a given firm and year, we multiply the value of the technology or management practice variable of interest by the value of the corresponding learning-by-doing (LBD) static capability variable. The expected correlation between emissions and these interaction variables is negative: Given some level of practice, we expect a higher level of LBD static capability to reduce emissions; and given some level of LBD static capability, we expect a higher level of practice to reduce emissions.

The two kinds of practice and capability tested here, with results reported in Table 4.13, are again management combined and technology combined, with capability computed with and without pre-IPC experience. All four partial correlations between emissions and practice-LBD capability interactions are negative as expected, although weakly for all but the technology interaction using the inclusive capability measure. These results are not inconsistent with Hypothesis 2 on the mediating role of capabilities with respect to the performance-practice relationship.

Above we have tested jointly for the explanatory significance of both the practice and the related static capability accumulated through experience with that kind of practice. It is also important to explore the complementarity hypothesis by pulling apart the interaction and examining the respective roles of each, practice and capability. We approach this by looking in Table 4.14 at the partial correlations between emissions and both management and technology practice and static capability. Management practices still appear significantly correlated with reduced emissions, and management capability does not play a statistically significant role; and while the technology practice correlation is reduced, its static capability is also not significantly correlated with emissions. This changes for technology, although not for management, in the final column: Allowing its capability variable to capture prior experience permits the expected mediation effect to appear, with the role of practice independently (controlling for capability) reduced more sharply while LBD capability displays a significantly negative association with emissions performance.

Static capability defined in terms of learning from experience acts as a complement with related technology practices in reducing emissions, when we account for prior experience alongside IPC experience. The apparent management practice-capability capability as modeled via interaction in Table 4.13 is apparently driven strictly by the direct effect of management practice on emissions. These results also suggest that LBD capability may take time to evolve. In what follows, as we turn to testing the role of dynamic capabilities in the development of static ones, we therefore focus on the LBD static capability measures that include pre-IPC licensing experience.

3.2.2 Dynamic capabilities

Dynamic capability should improve learning, and firms that are better learners should be more successful in implementing management and technology changes that improve environmental performance. Hypothesis 3 asks whether dynamic capabilities, via their role in creating new static capabilities, helped determine which firms adapted best to the new regulatory regime. We hypothesise that the performance-practice-static capability relationships will be stronger among the higher dynamic capability firms, and examine this for all three DC variables defined in Chapter 3: internal integration using EPA information, and both internal and external integration based on the 16 respondents to our mailed-out survey. The modelling strategy here is to divide the sample into the higher and lower DC firms so defined, then re-run the complementarity tests from the preceding subsection separately for the higher and lower DC segments, for each of the three DC measures.

For management, in the higher-DC segment Table 4.14's unsegmented result continues, even more strongly: no complementarity but a very strong practice-performance link, independent of static capability. In the lower-DC segment, completely against expectation, a powerful complementarity effect appears: management practice's association with lower emissions disappears (actually, is reversed), and there is a strong correlation between static management capability and lower emissions. While these results are interesting and will be discussed in the chapter conclusion, they do not conform to the complementarity hypothesis.

But the results for technology in Table 4.15 offer some support for Hypothesis 3. As predicted, there is no complementarity in the lower-DC segment; practice shows a strong association with improved performance independent of capability, which is not significantly correlated with performance. In the higher DC segment, the predicted complementarity relationships appear, with the independent effect of practice reduced and a significant association between static capability and lower emissions.

Turning to the survey based internal integration and external DC segmentations, we find no support for the hypothesis, although the tests are weakened by very low numbers of observations; for example, the below-median external integration segment has only five observations and does not permit statistical inference at all (zero degrees of freedom).

This data problem points out an interesting asymmetry in reporting across the segments in the EPA-based internal and survey-based external integration groups. For these two of the three DC measures, lower-DC firms report far less data than higher-DC firms. We infer from this that companies with higher levels of self-reported activity in systematically searching for and processing new information did better in meeting some basic demands of the (then) new IPC regulatory regime: tracking environmental impacts and reporting them along with practices thought to be relevant in reducing those impacts. This offers some indirect corroboration of our initial working hypothesis in this research, that dynamic capability would be important to adaptation and change. On the other hand, we cannot conclude that the data provide much direct evidence for this hypothesis.

What do our results tell us about the nature, evolution, and role of organisational capabilities? Our results are generally consistent with the idea that not just each year's technology practices are crucial to understanding performance (we tested this only for emissions), but also underlying learned-by-doing static technological capabilities. But this relationship is not revealed in the data with regard to management capability. In addition to affecting emissions directly, accumulated static technological capability also appears to complement ongoing technology practices in their effect on emissions performance. It appears that these relationships are somewhat stronger when pre-IPC period projects are accounted for in the static capability measures, suggesting that the experiential process of capability accumulation takes considerable time. As for the role of DC, the constraints imposed by our limited quantitative data on DC will be considerably loosened when we add qualitative insights from our interview results to the mix in (full report) Chapters 6 and 7.

4 Findings - Economic Performance Effects

In this chapter, we examine the relationship between the environmental efforts and outcomes experienced by IPC licensees and their economic performance. Many business leaders and scholars have argued that improving environmental quality must come at an economic cost, with a loss in efficiency among regulated firms. On the other hand, it is possible that companies that meet licensing requirements more effectively will reduce the regulatory cost burden, or even turn environmental performance into cost or revenue advantages.

4.1 Measuring Economic Performance

We have used Company Records Office (CRO) data to construct a measure of 'operating efficiency,' how effectively inputs are combined to generate cash flow: the ratio of annual earnings before interest, taxes, depreciation and amortisation to assets, where start and end of year assets are averaged to get a better representation of the scale of operation over the year the revenue and cost flows were generated. This is a measure of operating income generated by the assets; it is not affected by firms' differences in capital structure, choice of depreciation schedules, or one-off charges. Unfortunately, many firms in the sample fall below CRO's size threshold for required reporting of financial results. Only 29 have sufficient data to permit calculation of operating efficiency in any year, representing 115 facility-years in total, distributed across sectors similarly to the sector proportions in the full sample: 12 in metal fabricating, 6 in paint and ink manufacturing, and 11 in wood products and preservation.

4.2 Economic Performance and Environmental Impact

A starting point is to examine the statistical relationship between operating efficiency and the measures of environmental impact discussed in Chapters 3 and 4 ('environmental performance').

The method used is nonparametric correlation, for the reasons discussed in Chapter 4. The results (Table 5.1 in the full report) are partial correlations between operating efficiency and each environmental measure in turn, controlling for (holding constant) the effect of year, because both profitability and the environmental variables trend weakly downward over time.

Table 5.1 offers no evidence that higher economic performance accompanies better environmental performance *per se*, which would imply statistically significant negative correlations. The only statistically significant correlation is positive: Higher operating efficiency is weakly associated with heavier resource usage. These results are not consistent with the notion that 'it pays to be green,' and in the case of resource use fit with the idea that it will be costly to reduce impacts.

Nevertheless, it is possible that the simple specifications in Table 5.1 mask some relationships of concern. For example, both environmental impacts and profitability may differ by sector, for reasons that go beyond relative facility performance and have to do with basic characteristics of products, processes, and markets; these characteristics can interact with the relationship between impact and profitability at the firm level, but a simple a cross-sectoral sample can confound the relationships. In addition, whether impacts are high or low, IPC licensing and other forces are pushing firms to reduce them, and we would like to know how economic performance is affected by changes in – not just levels of – environmental performance. We take these possibilities one at a time.

Table 5.2 shows that the link between higher profitability and heavier resource use is driven by facilities in the metal fabricating sector. Indeed, this sector also shows that positive association in emissions as well. All the partial correlations for the paints sector and one of two for woods are negative, though only one is statistically significant: in paints, lower levels of waste are associated with higher profitability. These sectoral differences are interesting and potentially significant from a regulatory perspective.

Taken in combination, the results shown in Tables 5.1-5.3 suggest that, for these IPC-licensed Irish manufacturers, whether environmental performance exacts an economic toll depends: on whether we look at levels of or changes in environmental impact, and on the industry sector. Adding these refinements moves us progressively away from Table 5.1's suggestion that green is costly. It may be, but only in the metals sector, and only with respect to impact levels and not impact improvements. Low and reduced waste, in particular, tends to be associated with higher profitability. However, none of these correlations tell us anything directly about firms' greening efforts themselves, and what effect those efforts may have had on operating efficiency. We explore this question next.

4.3 Economic Performance and Organisational Response to IPC Licensing

We start by considering the relationships between economic efficiency and firms' IPC-related management and technology practices.

4.3.1 Economic efficiency and aggregate environmental practice

In testing the relationships between operating efficiency and the composite practice measures (Table 5.4), we control for the effect of time and the other practice variable, which is important due to the positive correlation between management and technology practices. While there is no significant statistical association between economic efficiency and management practice, the link with technology practice is positive and statistically significant: For facilities and in years with high levels technology practice, operating efficiency is high. It is possible that the direction of causation runs the other way, with stronger economic results permitting more technology expenditure. We control for this by lagging technology practice one year, since last year's technology expenditures cannot be directly attributable to this year's cash flow. The association is, if anything, a bit stronger for lagged technology practice.

It is also possible that the seemingly promising environmental technology-economic efficiency relationship in Table 5.2 is an artefact of a negative association between economic and environmental performance as (weakly) suggested above. Chapter 4 reports the strong possibility that especially for equipment investment, more serious environmental impact problems stimulate increased technology practice, rather than the causal arrow running from practice to environmental performance. The implication here could be that lower-performing facilities environmentally must undertake more technology investment to comply with the IPC process, and because they also are higher-efficiency, environmental technology falsely appears to improve economic performance. A way to explore this is to add a control for environmental performance to hold it constant in looking at the technology-efficiency relationship. Partialling out the relationship between key emissions and operating efficiency leaves the results mostly unchanged. It thus appears unlikely that Table 5.4's positive link between profitability and composite environmental technology practice is spurious and reflects instead the connection between each and environmental impacts.

4.3.2 Economic efficiency and disaggregated environmental practice

Chapter 4's analysis identifies specific kinds of environmental practices that are 'best' in the sense of most strongly associated with better environmental performance, and others that appear to have been undertaken defensively in response to poor environmental performance. It will help us understand the relationships among practices and both environmental and economic performance to see how those specific practices are related to efficiency, holding emissions constant. We begin by disaggregating technology practice to the level of pollution prevention approaches, focusing on unlagged technology since the discussion above suggests (and we have confirmed) that the lags do not affect the outcome.

The results in Table 5.5 suggest that the positive relationship between technology practice and operating efficiency may be driven in terms of approaches by closing the loop to capture and re-use product and/or materials that had previously become waste. On the other hand, substitution of more environmentally benign raw materials may be costly. Given that the woods facilities drop out when controlling by key emissions (see footnote), these results suggest that this effect may concentrate in that sector, where switching to less toxic preservatives has been the critical substitution. Equipment investment, which Chapter 4's results suggest is often defensive in nature, is not significantly related to operating efficiency.

Next we disaggregate technology practice by stage in the production process. Table 5.6 gives the results. In terms of production stages, the positive association between economic efficiency and aggregate technology practice reflects rather strong positive correlations at the core (basic) production stage, along with housekeeping-type practices for the metals and paints facilities (since the woods sector drops out when controlling for emissions). The latter suggests the economic potential of the range of practices capture here, such as recycling, spill prevention, and the like. On the other hand, technology practice in product design is associated with reduced profitability controlling for waste or resource use; this corresponds to Table 5.5's finding for materials substitution and again is likely driven, we believe, by preservatives change in the woods facilities that are excluded in the emissions controls. (Adopting less toxic preservatives is coded as a materials substitution approach at the design stage.) Finally, in two of three cells practice at the preparation stage is apparently costly, showing a negative correlation with operating efficiency; this result is interesting in light of Chapter 4's finding that practice at that stage is strongly associated with better environmental performance.

4.4 Economic Performance and Organisational Capabilities

4.4.1 Static capability

One of the core questions in this research is whether the ability to do certain kinds of things well in a given competitive environment – a 'static' organisational capability – can complement the practice-performance relationship by making particular practices more effective. We found in Chapter 4 some evidence that as experience accumulates with more projects and the passage of time using them, sample facilities did create static capabilities. An important question is whether a similar effect might extend to the economic performance associated with practices undertaken in response to IPC licensing. Our approach will be two-pronged: first, to proxy the complementary effect using a multiplicative practice-capability interaction term; and second, to use partial correlation to control for the respective effects of practice and static capability on efficiency.

In testing the interactions form we will again control for the relationship between key emissions and operating efficiency and, due to the strong management-technology cross correlations, use appropriate controls for each. Since the static capability measure computed to include the effects of pre-IPC licensing experience proved in Chapter 4 to be somewhat more potent, that is the version we use here. The results (Table 5.7) show that the management interaction variable is uncorrelated with operating efficiency. The technology interaction, however, is strongly, positively correlated: Given some level of static technology capability, increased practice is associated with increased efficiency, and given some level of practice, greater capability is associated with higher efficiency. These findings dovetail with those for practice alone, but with the effect of technology practice on operating efficiency amplified when its corresponding static capability is taken into account in this form.

We now move to the second approach to testing the complementary role of capabilities, pulling them apart from practice to examine the independent impact of each on operating efficiency in a partial correlation setting (Table 5.8). Neither management practice nor static capability are significantly correlated with operating efficiency here, consistent with the practice-only result. But both technology practice and static capability are independently, each controlling for the other, rather strongly, positively associated with economic performance. While this is not what is predicted by a partial correlation interpretation of complementarity in which holding constant the effect of the underlying complement (capability) would actually reduce the measured impact of the practice variable (Siegel and Castellan 1988). At the same time, the results here show that when measured independently, each controlling for the other, both technology practice and static capability are rather strongly, positively associated with economic performance. Each seems to play a role, and higher levels of both are linked with greater operating efficiency.

4.4.2 Dynamic capability

We are also interested in whether companies with specialised organisational capabilities for change – dynamic capabilities – developed stronger static capabilities during the IPC licensing period. Possible sources of this enhanced learning-by-doing effect, as described in Chapter 3 and tested for environmental performance in Chapter 4, are integration with sources and uses of new information, both internally and externally with respect to organisational boundaries. For each dynamic capability measure, we segment the facilities into higher and lower dynamic capability groups. The tests then replicate in each segment the two steps above, using the static capability-practice interaction term and then separating the two.

As in the unsegmented results, the results for the interaction terms (Table 5.9) indicate that the management practice-static capability interaction variable shows no significant correlations with operating efficiency in any of the dynamic capability segments. This changes for technology. Using both of the internal integration dynamic capability measures, the technology practice-static capability interaction is correlated with efficiency in the high but not the low dynamic capability segments – as predicted. (The correlation for the high external integration group is also fairly high, but given the small number of observations it is not statistically significant.) The efficiency-increasing interaction between technology practice and static capabilities that were acquired during the IPC licensing period appears here to be driven by those facilities with greater within-firm informational search and processing capability.

When we separate the practice and static capability components as done earlier, but now broken into low and high dynamic capability groups of facilities for each of the three measures (Table 5.10), no coherent patterns emerge. There are a few very large correlations, but they neither are consistent with our dynamic capabilities hypothesis nor suggest any particular alternative explanations. We can only conclude that these results are not supportive of the notion that firms' learning of new static capabilities varied by dynamic capability level.

4.5 Conclusions

Given the limited number of firms whose financial data permitted calculation of operating efficiency, this examination of the relationship between IPC responses and economic performance has produced some interesting results. The relationship between performance in the environmental and economic realms depends on the sector and the environmental impact measure: In metal fabricating, there is an association between higher levels of impact and of profitability in two of the three impact measures; but this is not true of the other two sectors, where for paint and ink facilities better performance environmentally and economically tend to go hand in hand. This more sanguine note continues if rather than environmental impact levels we look at year-to-year changes. Efficiency is not correlated along any dimension with increases in impacts, while for waste generation in particular it is associated with reductions in impact.

In addition, facilities' environmental technology practices are in many instances associated with higher levels of operating efficiency. Disaggregating technology practice indicates that the association may be driven by technology practices in loop-closing approaches and in the core production and housekeeping process stages. On the other hand, there are also practices that correlate with reduced profitability. Raw material substitution and product design have this effect, which is likely to be concentrated in the wood products sector where, apparently, the switch-over to less toxic preservatives has been costly.

It appears that static capabilities related to environmental technology practice emerged during the panel period and complemented the positive effect of aggregate-level technology practice on economic performance. Modelling this as a multiplicative practice-capability interaction variable, and also separating the two through partial correlation, both produce results consistent with the role of static capabilities. The evidence is far weaker for dynamic capabilities. Dividing sample facilities into low and high dynamic capability groups and replicating the interaction variable tests does suggest that the higher dynamic capability firms exhibit stronger static technology capability effects, i.e., were better learners. But repeating this for the separate practices and static capabilities partial correlations provides no support for the dynamic capabilities hypothesis.

On balance, the results reported here mimic the broad findings in the research literature that whether it pays to be green depends on many factors, including industry sector and what dimension of environmental performance is of concern. The methodologies presented in this study for measuring and testing the variables of interest allow us to identify at a fairly fine-grained level what those contingencies are for this group of facilities. Our understanding can be further nuanced by bringing to bear results from survey responses and in-depth case interview with a smaller number of firms, to which we now turn.

5 Findings – Dynamic Capability in Operation

Case study and survey research was used to complement the larger scale statistical analysis. The postal questionnaire was a means of gathering richer company-specific data in addition to the information gathered from the EPA files and publicly held financial records. The cases provide the best available look at the role of dynamic capability. The issues it entails, moreover, are well suited to qualitative and contextual examination. This analysis allows us to draw out lessons about what makes for successful environmental management within companies, and how this may be fostered by companies themselves, as well as supported by the regulator.

Table S5.1 **Survey Response Rate**

Sector	No. replied to survey	Response rate from full sample	Response rate excluding closed companies	Response rate from those used in stat. analysis	Response rate from those used in stat. analysis excluding closed companies
Metals	7	24%	33%	29%	35%
Paints	5	28%	50%	38%	50%
Woods	9	29%	30%	20%	21%
TOTAL	21	27%	34%	27%	31%

Firms for case study were chosen for variation in industry sector, and in results (some that exhibit the combination of high performance and explanatory variables identified in the statistical results, and some that do not); and for willingness of management to cooperate with researchers.

Table S5.2 **Interview Response Rate**

Sector	Number interviewed	Response rate from full sample N = 78	Response rate from those used in statistical analysis (excluding closed) N = 51
Paint	5	28%	50%
Metal	8	28%	47%
Wood	0	0%	0%
TOTAL	13	17%	25%

One-to-one interviews were conducted with senior managers responsible for environmental management in thirteen sample companies. In the interviews we asked managers about key cleaner technology projects, identified from the company's AER reports, and then probed further to explore the management processes that supported the identification and implementation of that project. We also discussed the company's experiences in managing its environmental responsibilities.

5.1 Capability for environmental management

One of the advantages to companies of having an IPC licence is that it provides a lever for the environmental manager to gain commitment from top management and from staff to prioritise environmental improvement and formalise environmental management.

> Paint4: 'From my point of view a great benefit is to be able to go to senior management and say I need to get this site cleaned up or we need to take a closer look at our waste.' Previously it was difficult to 'get the point across that we actually had to go and do it.' 'There is more awareness through the general population [of staff] … changing the culture.'

In the survey we asked how influential environmental issues are on discussions about company strategy. Eight respondents (38%) said environmental issues are 'very' influential, twelve (57%) said they are 'somewhat' influential and one (5%) replied that they have a 'minor' influence. Respondents were also asked whether progress and problems in addressing the requirements of

IPC licensing entered into discussions about company strategy: twelve (57%) said ‘regularly’ while the remaining nine (43%) replied ‘sometimes’. Six respondents (29%) also stated that the influence of the environment had changed during the time the company has had its IPC license. The IPC license and environmental issues are an integral part of discussions on company strategy and over time, these issues have become more important and influential.

As well as appreciating the IPC process for the focus it gives to environmental issues within the company, interviewed companies described a range of other benefits from having environmental management in place, and very few companies maintained there was no benefit. Companies reported being able to use their environmental management as a marketing tool, with advantages for selling to larger corporate clients, qualifying for tendering processes and differentiating from competitors. Some companies have used IPC compliance as an opportunity to drive technology upgrading and process improvements. And there are many companies that have achieved cost savings through projects to improve resource usage and eliminate wastes. There have also been important softer benefits, such as managing site risk and improving worker conditions.

A less obvious benefit to companies of ensuring they have good environmental management is avoiding the consequences of weak environmental management procedures. Companies with poor environmental control end up in situations where resolving the problem absorbs large amounts of financial resources and management attention. In the companies that we visited that were facing these kinds of problems there was often a full-time or near full-time environmental manager, other environmental support staff, as well as high involvement from top management. One company we spoke to had the attitude that compliance was not a major issue and environmental matters were given no more than two hours a week as part of the environmental officer’s other responsibilities. This company expanded operations without considering the licence implications and ended up being required to undergo an extensive licence review process. Companies that fail to resolve environmental management issues find themselves under increasing scrutiny from the EPA, with increased site visits and monitoring requirements. Furthermore inadequate environmental management can end up acting as a severe limit on the company’s ability to operate. Inability to resolve high emissions can force companies to cut back on manufacturing. One company had a situation where a solvent based product exploded, resulting in a prohibition order preventing solvent based manufacture until procedures to prevent reoccurrence were put in place.

A good example of the negative and positive sides of environmental control is a company that was prosecuted in 2003, followed by a licence review, and had to undertake extensive efforts to improve environmental management. They reviewed all their processes, reorganised site procedures, eliminated some raw materials and changed processes. They improved their environmental control, their working conditions and their efficiency. Now the company is in a position where they are considered to be a low risk site and have reduced auditing by the EPA.

5.2 Cleaner technology

The case profiles show the range of technologies pursued by companies in managing their environmental impacts. Companies are implementing product redesign, process changes, raw material substitutions and housekeeping efforts. Often projects are carried out at the margins of the manufacturing process, avoiding recongiguring of the core processes. Paint2: 'anything like that that is doable, that is easy, that doesn't cause any hassle, because otherwise …' An exception is reduction in solvent use, which has been extremely challenging for both sectors we looked at, requiring changes to equipment, materials and processes, involving extensive cooperation with suppliers, as well as education of customers.

The majority of major projects identified by companies in the case study interviews were projects that achieved an economic return and were not very disruptive to the main manufacturing process; examples include looking at washwater, packaging reduction, changes to cleaning processes. They are however projects that require implementation and integration, not just drop-in solutions. Even simple projects such as reducing packaging waste involves negotiating with suppliers to make changes, with new processes and equipment. Changing cleaning processes involves trials of new materials and changes to internal routines.

A number of companies had identified where a waste stream could become a useful input into another product or industry, providing a closed loop solution. These projects often require integrating processes across the companies involved, as well as securing permissions for the transport of waste. Reusing waste streams in this way is of particular economic and environmental benefit in Ireland, where the limited scale of industrial activity means that specialised waste often has to be shipped abroad.

Benefits to these projects come from a number of sources: companies save on materials costs, on waste disposal costs, on maintenace costs, on labour costs, on better quality of results and on enhanced worker conditions.

In the quantitative analysis we identified an unexpected association whereby companies with higher resource use and waste undertook higher levels of technology projects. Reverse causality is the idea that, instead of a high number of projects producing strong environmental performance and lower emissions, in these cases poor performance has triggered the adoption of projects to respond to the problem and reduce waste and resource use. The leverage factor discussed above may explain some of what we are seeing here. A number of companies that we interviewed identified an environmental crisis brought on by prosecuting or threatened prosecution by the EPA for long-standing and unresolved pollution. This crisis then enabled to environmental manager to secure top management commitment to environmental management, and an increase in resources to invest in remedial projects and systems. These companies often adopted a multi-pronged approach, with improvement projects in a number of areas, or a number of technologies to deal with one problematic area. We also interviewed many companies where the high costs of energy resources and higher waste disposal charges had led the identification of these as areas to be targetted for reductions.

5.3 Dynamic capability for continuous environmental improvement

In some of the companies we studied strong processes for continuous environmental improvement, can translated into a programme of technology projects and a strong environmental performance, as well as supporting the integration of environmental management with broader company goals. In others the negative impact of a lack of dynamic capability can be seen in struggles to manage the impact of environmental compliance on the business, often with an adversarial relationship with the regulator, and a significant amount of time spent in disputing licence requirements.

5.3.1 Identifying areas for environmental improvement

Developing a programme of environmental technology projects starts with deliberate efforts to plan for such projects, Successful companies put in place activities to identify significant environmental impacts and then search for solutions. Two key processes are (i) collecting environmentally salient data and using it to make informed decisions about environmental improvement and (ii) planning in regular times for considering environmental improvements.

> Metal8, with the highest level of technology projects in its sector, holds regular meetings of the environmental improvement group, every two months.
>
> Paint1 holds committee meetings (management and SHE committees) every two months to discuss options to continually improve the company’s performance.
>
> In Metal5 the project team meet on a regular basis, every two months, to discuss progress in green product development.
>
> Paint4 and Metal6 are companies that are still developing their environmental capability. They are both systematic in the collection of data on environmental impacts to direct their improvement efforts.
>
> Metal7 is another company that collects and uses data to ensure improvement efforts are targetted on the areas of biggest potential return, meeting every two months to identify and progress projects.

5.3.2 Implementing solutions

Implementing projects in areas that are new to the company requires processes to develop learning. Companies that are successful in developing cleaner technologies make sure that they involve a wide range of expertise in these projects, at the planning and the implementation stage.

> At Paint1, there was evidence of cross-functionality between departments, with operations, SHE, site resources and quality assurance working together on the same projects. During the case study interview, the interviewee stated that the company had a policy of including all relevant people from the shop floor up in the projects they conducted, as they had learned that it was very difficult to get buy-in without involving staff. They also saw that it was an excellent way of generating new ideas through brain-storming and of involving staff by encouraging them to implement their own ideas.

Projects that required capital expenditure were passed onto management for approval; otherwise projects were implemented on the shop floor.

Metal5 also regularly made use of teams and inter-departmental cooperation on environmental projects. Team members included R+D, technical, production, EHS, marketing, quality and finance staff. During interview, the interviewee said that teams were frequently used for product design and production technologies modifications. The company used teams from different departments and across sites (chemical, mechanical, environmental, H&S, marketing etc.) to work on new projects. They met every two months to discuss progress on the new product/project. Pressure from customers to produce more environmentally friendly products had lead to more teamwork to achieve this.

Cross functionality between departments and teamwork was mentioned several times in Metal1's AERs, specifically when dealing with IPC compliance, costs, energy reduction and waste reduction. The company established a project team to focus specifically on lowering their emissions to water (an on-going problem); the team included the manufacturing manager, the metal finishing supervisor, the head of metal finishing and a project manager.

The survey data supported the common but not universal use of teams in industry. It also shows that companies are more likely to use teams for general rather than environmental projects.

Table S5.16 Use of teams

		Uses teams for environmental projects			
		Regularly	Sometimes	Rarely	Total
Uses teams for general projects	Regularly	3	4	1	8
	Sometimes	1	7	2	10
	Rarely	0	0	3	3
Total		4	11	6	21

This may suggest that environmental projects are not as integrated into the organisational fabric of the company as other projects are which can inhibit the longer-term success of environmental improvement efforts.

5.3.3 Building competence

Successful companies have processes or policies to capture learning. This can be capturing internal knowledge, by using cross functional teams, and by building on prior learning by maintaining an environmental improvement group. It can also mean taking internal control of areas of new expertise, rather than subcontracting them to consultants. This is more costly/disruptive in the short term, but has long run dividends in increasing the capcity of the company. These processes can allow companies to pull together necessary resources for environmental management projects, without needing a full-time environmental manager.

> Paint4 used consultants to help achieve ISO 14001 certification; however, if they were to do it again, the interviewee believed that they would do it entirely in-house. He felt that the consultants wrote a very generic policy and manual, and he ended up spending significant time to understand and personalise it for the company.
>
> Metal6 conducted a licence review in 2005-2006. The interviewee thought that the process was of great benefit to the company, as they did it internally rather than using external consultants. It gave them the opportunity to closely examine their processes (many of which had been in place for years), think about more efficient ways of doing things and ultimately the company made several positive changes as a result.
>
> Metal7 also saw the benefit of not using external consultants. The interviewee stated that the company did not use consultants as they preferred to work on solutions themselves and therefore learned new skills and kept new information and expertise in-house; thus the company benefited as a result. The company had no R+D department and sourced information from the internet, trade journals, research reports, suppliers

Another route for capturing knowledge is for the environmental team to work with external experts to learn from them. Impartial advice was greatly appreciated by the case companies, who accessed sources such as Entreprise Ireland, IBEC, CTC, and UK trade organisations. This type of advice is different to outsourcing responsibility for a project to consultants, and also different to purchasing an off-the-shelf solution from a supplier. Both specialist consultants and suppliers are an imrortant source of technical solutions for companies, but the most successful companies are those that plan such projects with a view to developing internal competence as part of implementation.

5.3.4 The role of perception in managing environmental responsibilities

Companies that manage environmental compliance successfully are those that see the licence as an opportunity for change within the company. There are many examples of companies that combine licensing with upgrading of technology, with the development of superior products and with cost reduction programmes. Having a positive approach in the way the licence is viewed is the starting point for these processes, not the outcome. Companies that have the perception that the licence is an unfair imposition, and who stay in a stance of resistance are companies that retain a compliance focussed mindset and do not see opportunities to work environmental management in a way that reinforces broader strategic goals. This further reinforces their perception of the extreme demands of environmental compliance as their reactive approach often results in the operation of the licence being more binding.

5.4 Other factors impacting on environmental performance and cleaner technology adoption.

Environmental regulation is not the only factor affecting the environmental performance of companies. They have to reconcile a range of external factors that both work against or in favour of improving the environmental impact of their activity.

Product advances often provide an opportunity for designing out environmentally harmful substances, such as solvents, but customers are often slow to embrace new products. Poor customer response can inhibit further investment in these technologies.

EU directives are accepted by companies as something they have to anticipate and respond to. They operate across all companies, licensed or not, and across all markets – the pain of adjustment is felt by all their competitors too. It also means that their international suppliers are also responding to the directives and providing support and inputs to help them meet new requirements.

Environmental regulation aimed at moving companies towards clean technology is described as ‘win-win’ because being environmentally conscious with resources and wastes is usually also cost saving. For the companies we spoke to the win-win often works the other way round – that projects driven by cost considerations have an environmental bonus. This is true of production costs, and also as market prices for energy resources and waste disposal rise.

Many of the paints companies are moving out of solvent based products and also moving out of milling/blending in favour of new production technologies such as in-can tinting. Similarly, many metals companies are discontinuing processes, either because of EU directives, lack of market demand, or by a loss of competitiveness with production in emerging economies. Their production mix is moving to a less environmentally adverse profile, but shaped by other economic and regulatory factors.

Environmental improvements can be driven by other factors besides environmental management and regulation. In our case study research we found a number of companies who actively take advantage of this by coordinating environmental management efforts with general efficiency and upgrading.

5.5 Environmental regulation and competitiveness

While the research did not seek to establish the cost of environmental complaince, some companies indicated the significant impact on their business, and especially on their relative competitiveness. This is supported by the research of Clinch and Kerins (2002) who estimate environmental costs in the surface coatings sector, for the three years between 1997 and 1999, at approximately €200,000 per company, including almost €45,000 for admiinstrative costs. There were a number of cases of companies, among the companies we studied, reducing production in a direct response to being subject to an IPC licensing. More encouragingly, when asked directly, companies were approximately evenly split between those who see environmental management in the IPC program as having increased or decreased their economic competitiveness.

Table S5.21 Overall Impact of Environmental Management

	Frequency	Percent	Valid Percent
Increases competitiveness	8	38.1	40.0
Decreases competitiveness	9	42.9	45.0
Neither	3	14.3	15.0
Total	20	95.2	100.0
Missing	1	4.8	
Total	21	100.0	

The economic impact of IPC licensing on companies is non-trivial. Clinch and Kerins (2002) note that the dynamism of the Irish economy since IPC was introduced in 1994 has softened the impact of the environmental regulation. While there is broad societal agreement that the costs of pollution must be borne by the polluter, it is also important to keep in mind the societal benefits of economic activity and therefore to seek to achieve our desired level of environmental protection at the least economic impact.

5.6 The role of the regulator.

The purpose of this project was to investigate environmental problem solving in IPC licensed companies. Inevitably, companies wished to express their views on their experience of being licensed. We report some of these comments here for what can be learnt about improving the ability of companies to engage in continuous environmental improvement.

5.6.1 Perceptions of fairness in environmental regulation

Companies generally accept the EPA’s role in protecting the environment. However, where the burden of compliance falls unevenly, there is a perception of unfairness and unreasonableness. Many companies referred to a lack of fairness in the way the IPC licence is administered. They are sensitive to the competitiveness implications of a licence, especially if it falls unevenly across a sector of competitors. They feel aggrieved when other companies are not licensed, or licensed more leniently. IPPC licence thresholds are determined on the basis of the plant’s capacity to emit key pollutants. For the paints and metal coatings sector, those activities with the capacity to make or use 10 tonnes or more of solvents require an IPPC licence. For the wood treatment sector, those activities with a capacity greater than 10 tonnes of wood per day require an IPPC licence. Companies that fall within and outside the remit of the IPPC regime compete with each other. Clearly it is difficult for the EPA to resolve this tension; the regulations are currently sensitive to the scale of operations, but still competing firms are carrying different regulatory burdens. If a company’s attitude to being licensed can be influenced by the regulatory stance, and if this then translates into a greater willingness for companies to accept and not resist their environmental responsibilities, then there will be benefits to the regulator, industy and society.

Companies frequently expressed frustration where licence conditions or enforcement appears unreasonable. This if often where the reporting requirements are unnecessarily onerous or repetitive. Another aspect of this is where the EPA changes policy or introduces new policies without communicating the change. Similarly, when they they do not understand why they are asked to monitor a particular impact, companies start to lose commitment. Where the licensing is aligned to the way companies do business, it is seen as being legitimate.

The EPA's approach can also lead to resistance rather than promote active engagement with IPC. While clearly the EPA has to act on pollution non-compliances and has enforcement as a central mission, this should be balanced with longer term objectives to encourage real engagement with environmental continuous improvement by companies.

5.6.2 Support for environmental management

Companies express frustration when they are making efforts to meet their licence conditions or develop technology projects but they cannot get information from the people they identify as being the experts, the EPA. Again, there is a perception of unreasonableness that they are being pushed to make changes, but without much guidance. Views on this aspect were divided, and there was evidence from companies with very constructive relationships. Some companies also expressed surprise that the EPA does not function as a source of learning, disseminating knowledge of best practice from the experiences of other IPC companies or technologies developed elsewhere. There were a number of examples of companies that have implemented very effective off the shelf technologies that are widely available but not adopted in Ireland.

> Metal4 'If a small company could interact with the EPA in a practical manner where they got advice as well as knuckles being rapped, then that would be fair.'

5.7 Lessons for companies

> The company culture with respect to change is a significant factor. Companies that perceive their environmental obligations as an integral part of their management priorities are better able to manage regulatory requirements and take opportunities to minimise the impact.
>
> Teamwork and inter-departmental cooperation maximises the expertise brought to bear on a problem or project, as well as increasing broad commitment to the project, increasing its chances of successful implementation. It is also key to make continuous environmental improvement into a routinised management task, with established processes for data collection and regular planning and decision-making.
>
> In learning about new approaches, the companies often access external sources of help and advice. Some companies outsource tasks to external specialists, without internalising any knowledge about the project. Capability is developed where companies retain internal

control of the project, but commit to learning what is required with the help of external experts.

5.8 Lessons for the regulator

The legitimacy of the EPA is undermined when companies do not respect the agency and their inspectors. If companies start to feel a disconnection between their efforts and any real environmental benefit, this can lead to poor engagement with the IPC process. IPC licensing has the aim of compliance with environmental standards, but it also aims to be developmental, to encourage the establishment of environmental management processes and routines of for continuous environmental improvement. It is this more fundamental aspect of the licensing that has the potential to reconcile environmental protection with economic impact. It is also the aspect of the licensing that is most vulnerable to company perception and attitude.

Companies need to acquire knowledge outside their expertise to implement environmental technologies. There is a lot of frustration that the EPA cannot be more of a resource and support to companies. Interviewees point to other forms of regulation and audit where the relationship is one of partnership as well as enforcement.

Views on the role of the EPA in providing support and guidance to companies in making changes to meet their environmental obligations are mixed. There are companies that have very constructive relationships with the EPA. This suggests that there are differences between individual inspectors, and perhaps provides an opportunity for the EPA to adopt this more proactive stance across all inspecting teams.

There were a number of examples where companies were able to develop creative solutions to waste problems by cooperating with another company who could reuse a waste stream in their production. There is an opportunity here for the EPA to foster such arrangements, by recognising their benefits in their enforcement of the licence, and also by acting as a facilitator or broker.

There might also be an opportunity for the EPA to increase the sector-specific experience of their inspectors by encouraging sectoral specialisation and information exchange, even without moving from the current regional organisational structure. If the EPA are able to develop as a resource, they may find being knowledgeable about the industry they are regulating improves the effectiveness of the licence, as well as improving environmental performance.

We are sensitive to the difficult balancing act that the EPA has to perform in satisfying all of its stakeholders. Strict enforcement is being used to meet the expectation of society that the EPA will regulate and reduce the environmental impact of industrial activity. But the EPA also has an interest in society's more subtle goal: to balance environmental protection with economic development, which is also in the interests of society.[7] As one of the environmental managers we

[7] It could be argued that this balancing happens at a European level in the determination of the best available technology (BAT) for a sector: technology which firms could employ and from which

talked to said ‘the only way this company can be 100 per cent environmentally friendly is to close…other than that you have to balance economics with environmental performance.’

6 Conclusions and Recommendations

Perhaps the broadest policy relevant finding from this research is the diverse evidence that the IPC licensing program worked. While we discuss specific accomplishments, it is important to note at the start that during the 1996-2004 period studied, these facilities’ overall environmental performance seems to have improved. The environmental impact measures devised here trend gently downward with time, as indicated in the correlations reported in Table S6.1. (The result for combined resource use is driven by electricity and water reductions.) While the correlations are small, and hover around the edge of statistical significance; in addition, they refer to environmental impact variables that are normalised by employment, and decreasing per worker impact could be swamped by growth effects. Nevertheless, their regulatory significance is that a program like IPC licensing can induce companies to move toward cleaner production.

Table S6.1 Simple Correlations:
Environmental performance vs time

(Probability values and observations in parentheses)

	Correlation with year
Key emissions	-.119 (.133, N=160)
Total waste	-.144* (.063, N=167)
Combined resource use (electricity, fuel, water)	-.189* (.058, N=101)

*Significant at 10% level (two-tailed).
Based on Spearman’s rho.

Gradual improvement overall in environmental performance is consistent with the evidence that emerges here that the management and technology practices employed by these facilities, as they responded to the IPC licensing requirements, were associated with specific impact reductions. Lower levels of key emissions, in particular, were associated with increased management and technology practice at an aggregated level, and with disaggregated types of both that are pinpointed in the results reported in Chapter 4. The results for waste and resource usage are more complex, given the apparent dynamic of facilities with more serious environmental impact

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are derived the achievable emission limit values that can be set in IPPC licences. The technology (and hence the ELVs) is selected on the basis of being both technically and economically viable to implement, a determination which then may be made for individual licensees using a case-by-case assessment of costs and benefits however the end result must still ‘ensure a high level of environmental protection’ meaning that ‘the most appropriate techniques cannot be set on the basis of purely local considerations’. (http://www.epa.ie/whatwedo/advice/bat).

problems then undertaking elevated levels of practice in response. While we do not find specific evidence that particular practices ultimately reduced particular impacts, nevertheless those impacts were reduced over time, as noted above.

We also find evidence that as companies accumulated experience with IPC-related technology practices, they created new organisational capabilities that complemented the direct effects of those practices on performance. Companies learned by doing, and this helped them reduce environmental impacts in line with the policy aims of the IPC licensing program. The evidence suggests that early experience weighs heavily in this process. The implication for policy is that early involvement pays dividends, and delay (in coverage or in strong engagement with the program) may be costly. It may be worthwhile seeking means by which early movers can be induced to share environmental experience with relative newcomers.

While the limited statistical results we could assemble on specifically dynamic, change-oriented capabilities did not provide evidence of their importance, the case interviews did. Companies that actively sought and integrated new information on environmental management and technology reported higher levels of performance, especially if these processes were self-organised and not farmed out to a consultant. Impartial outside information sources were reported to be at a premium. Some interviewees argued that EPA could offer a valuable service in this regard by providing more informational and technical assistance, a point to which we return below.

Finally, both the statistical results from Chapter 5 and the survey responses in Chapter 7 suggest that on balance, the enhanced environmental effort and outcomes noted above did not come at the cost of reduced economic performance. Operating efficiency was actually positively related to facilities' levels of environmental technology practice. It appears that IPC regulation did in many instances stimulate the kinds of cost-reducing 'innovation offsets' that Michael Porter (1995) and others have claimed. From the public's point of view, EPA should be seen as having encouraged environmental quality without on balance creating an economic burden.

Nevertheless, the course of our research suggests, with some corroboration from the case interviews, that IPC program design could have been more efficient in certain respects. It is to this point and its implications for IPPC licensing and further program development that we now turn.

6.1 Recommendations - Standardisation

The IPC licensing process is based on facility-specific requirements for monitoring, reporting, and limiting particular environmental impacts. The specificity includes what emissions are covered; where, how, and when they are to be monitored; what levels are to be permitted; and how they must be addressed. The approach is in broad principle consistent with the widely shared understanding that environmental impact is highly context-specific by nature. But we will argue in this section that in practice, the nature and degree of specificity imposes unnecessary burdens on both EPA and licensed firms, ultimately compromising the effectiveness of the program.

Even within the same licensing class, into which facilities are grouped according to their most important environmental impacts, covered emissions and related requirements vary widely company by company. This degree of customisation means that EPA staff must design, monitor, and enforce as many regulatory packages as there are licensed facilities. Despite what seem to these researchers to be high levels of effort by skilled and dedicated staff members, the quality of the self-reported data in the files is inconsistent at best. We suggest that a reason may be the difficulty of tracking and ensuring compliance with such large numbers of highly detailed but disparate license regimens. Smaller numbers of indicators, more standard across relevant groups of licensed facilities, would likely result in more time for inspectors to ensure reporting compliance and, hence, better quality data.

While of course the policy goal is not to enhance convenience for researchers, nevertheless the difficulties encountered during this study in assembling comparable indicators from a myriad of distinct company reporting regimes may be clues to an additional problem. It is important that the results of regulatory programmes be capable of objective assessment. And to the degree that common requirements are set for comparable groups of firms, assessment is facilitated. Here the agency's company-specific approach creates a hurdle. This barrier is further heightened by the divergence between EPA's licensing classes and standard industrial sector classifications. Policy-relevant research such as the EU's MEPI study typically organise findings and compare performance by standard industry classifications such as NACE, and if cross-national program comparison is a policy goal here, then more standardisation may be desirable.

A final related issue has to do with the licensed firms' perceptions regarding the fairness of the program. It is to be expected that licensees may complain about having to meet regulatory requirements. But it is possible that sometimes the level of monitoring and reporting detail entailed in these facility-specific licenses gives rise to more difficulty and occasional resentment than is warranted by the results. In addition, differences in regulatory treatment of similar firms has been observed to engender additional resentment. A perception that the playing field is not level is not conducive to willing compliance and active engagement.

6.2 Recommendations - Enforcement and Assistance

The foregoing issue leads to a set of observations based on the survey responses and, especially, the case interviews. The perception among some companies that they were subjected to arbitrarily harsher treatment than their competitors was a subset of a more generalised view that EPA should offer assistance as well as enforcement. We have suggested above that, to the extent there is any merit in this view – and we certainly recognise the tendency to bias in such views – it may be partly traceable to the policy of facility-specific requirements. But it is possible that there are opportunities for a more assistance-oriented role for the agency.

Two kinds of possible assistance were raised in case interviews. One is to take as a major task the dissemination of information about best practices to licensees. The state of knowledge about the sources of environmental impact and the options available for reducing them is constantly changing. The most common source of relevant information for these firms is through vendors and consultants, and while these may be important conduits in some cases, in general the company representatives interviewed expressed dissatisfaction and even suspicion regarding the quality of information conveyed. Several voiced the wish that EPA help fill this gap. It may be that dedicated programmes and staff in this area would be both useful to licensees and conducive to more uniformly positive company-agency relations. This assistance should be provided recognising that the most successful companies are those that access assistance in a way that develops internal competence as part of implementation.

Cross company learning would also be facilitated by a move to smaller numbers of indicators, more standard across relevant groups of licensed facilities. Companies would have more in common, allowing them to share best practice. The EPA licensing team might gain more common experience across the group of licensed companies, allowing them to act as a transfer of knowledge.

Another request we heard was for EPA to assist licensed firms by serving as in effect a broker, helping match companies having marketable waste streams with those that could benefit from access to them. We do not know the extent of the possibility for such a role, if any, but the idea is indicative of the frequently heard desire for the agency to find ways to augment its perceived enforcement focus with others more oriented to partnership.

Like any environmental regulator, EPA must address the often divergent needs and perspectives of many stakeholders. Ultimately, its responsibility lies in fulfilling the public trust for protection of Ireland’s environmental assets. The research findings reported throughout this study support the proposition that the public’s interest has been well served by the IPC licensing program. We hope that the suggestions raised in this concluding chapter may provide some small input as EPA moves forward in its work.