1 Study Background

1.1 Aims and Objectives

The major aim of this research is to identify and weigh the importance of factors that promote and constrain, the adoption of environmental initiatives by small and medium sized enterprises (SMEs). The objective is to inform how policy can overcome obstacles so as to promote the adoption of cleaner technology (including environmentally sensitive products (Oosterhuis et al. 1996)) by industry. *Central to the research is the testing of a set of hypotheses, which, inter alia, relate the adoption of cleaner technologies to competitiveness, management culture and the importance of the provision of information.* The manufacturing sectors considered are those dominated by SMEs where product *and* process environmental response by the firm is important. Of these sectors, furniture, textile finishing, and fruit and vegetable processing were chosen. More specifically the focus is on European SMEs i.e. those employing less than 250 employees.[1] Variations within the EU with respect to environmental regulation are exemplified by a study of firms (and plants) across four member states: Germany, North-east Italy, Republic of Ireland and the United Kingdom.

The adoption of clean technologies has been slow and uneven and action has mainly involved good housekeeping. Major changes involving large capital spending, or material substitution, process redesign or reformulation have been relatively rare (OECD 1985, 1995; Ashford 1993). The problem is particularly acute amongst SMEs (and the majority of enterprises are SMEs; e.g., two-thirds in Germany) because they are additionally handicapped by a lack of information and resources to invest in cleaner technologies (OECD 1990). While the dominant influence on a company's investment in environmental initiatives is the need to comply with regulations (Irwin and Hooper 1992; Whitaker 1993; Department of the Environment 1994; Green et al. 1994; CIA 1993), survey data indicates that many businesses are not fully aware of their legal environmental responsibilities while, some managers go beyond the "compliance only" approach and see benefits to be derived from an effective environmental programme (Winter and Ledgerwood 1994).

The widespread use of clean technologies depends on more than just technological factors and the return on investment and this study focuses on three interrelated hypotheses that recur in the literature. These are concerned with the impact of clean technology on firm competitiveness (and the influence of firm competi-

[1] In this study an upper limit of 500 employees has been taken for technical reasons.

tiveness on the take up of clean technology); the relevance of management's environmental awareness/culture; and the availability and quality of external information sources, including those arising from relationships and linkages to the firm (namely, trade associations, universities, R&D organisations, official government sources, business to business networks, environmental consultants, customers, suppliers etc.).

1.2 SMEs and Clean Technologies[2]

Small and medium sized enterprises are important to all European economies. They create jobs, are a source of innovation and competition, create a dynamic, healthy market economy and preserve a stable economic base. Despite considerable efforts by governments to inform SMEs of the potential economic benefits from positively managing their environmental performance and investing in clean technologies, investigations and surveys, indicate that many are still:

- unaware of relevant legislation,
- unconvinced of the potential cost savings and market opportunities,
- out of step with their customer's requirements,
- disassociated from their stakeholders' concerns.

Indeed, most SMEs see no reason to address the environmental aspects of their businesses. Any action taken is often a response to legislative and regulatory pressures rather than positively seeking new opportunities from environmental management. SMEs appear passive or at best reactive on environmental issues, displaying none of the innovative characteristics associated with the sector.

The message does not even get through on the need to comply with environmental regulations. This can partly be explained by the fact that SMEs are unreceptive or unable to interpret the relevance of the legislation to their business. Moreover, SMEs are expected to have expertise in a whole raft of complex regulatory areas such as tax law, VAT and employment law. These can be much more pressing than environmental legislation, in part because they are more fundamental to the operation of the business and because they are enforced more effectively.

Consequently, SMEs appear powerless to do anything about their environmental performance and do not fully recognise their contribution to environmental problems. Few seek the help available because the support services do not match their needs. Furthermore, smaller businesses lack the time and money to investigate their environmental performance or access the high cost consultancy support network. Despite the ability of large businesses to link product quality and cost savings to environmental performance, SMEs lack the internal skills to respond to new demands or at the pace required. Finally and most importantly, SMEs lack the

[2] See Appendix S3, Clean technology adoption by firms, M Vasilopoulos in Hitchens et al. (2001). Sects. 1.4 and 1.5 also follow this Appendix.

financial potency or funds for R&D to keep abreast with technological improvements.

In general small companies:

- have limited financial resources,
- believe that environmental issues represent low priority,
- are unfamiliar with the concept of clean technologies,
- wait for compulsory regulation instead of anticipating future requirements,
- lack know-how as regards environmental regulation and technological developments.

While this may describe the average position of the environmental performance of SMEs, there are nevertheless cases where the use of clean technologies and the environmental performance of firms are above the average of SMEs in each industry.

This study focuses on the characteristics and experience of those above average environmental performers, in comparison with the average performers in the industry, and more specifically it seeks to test the following hypotheses to explain an above average take up of environmental initiatives.

1.3 Main Hypotheses

(i) The relationship between investment in environmental initiatives and firm competitiveness is likely to involve positive feedback in both directions

While clean technologies are expected to have consequences for the competitiveness of firms, the fact that the firm is characterised by above average competitive performance may lead to the early adoption of clean technologies.

The competitive performance of firms may be defined from the input or output side (Jacobson and Andréosso-O'Callaghan 1996). Where competitiveness is defined from the input side (i.e. representative of the likely explanations of competitiveness) the measure is based on strengths in physical and human capital endowment, R&D spending etc. These are also factors that are known to influence the adoption of cleaner production technologies (Green et al. 1994; OECD 1985, 1987, 1995; ECMT/OECD 1994; Wallace 1995). Furthermore the above average competitive performance of the firm implies that it also has the management capability to respond to environmental pressures with best practice solutions. These input hypotheses are considered in Sect. 1.3.

Output side indicators of competitive performance: profitability, market share, productivity, patents, firm growth etc., not only measure (in principle) the consequences of the adoption of clean technologies (ENDS 1994; CBI 1994; OECD 1987, 1995; Porter 1990), but also provides the resources and opportunities for the adoption of cleaner production methods and products.

Where investment in environmental initiatives arises through environmental regulation, there is no convincing evidence that this affects competitiveness (Cropper and Oates 1992; Jaffe et al. 1995; Glass 1996; Ekins and Speck 1998). Porter and Van der Linde (1995) go one step further to advocate the existence of benefits and substantial first mover advantages from the early application of environmental technologies. The question that arises here is whether those firms that go beyond compliance only (with regulation) depress or improve their competitive performance.

(ii) The role of management and the culture of the business organisation is important to the take up of environmental initiatives

Some managers are more likely than others to "internalise the externality" of environmental effects i.e. they will seek to avoid negative environmental outcomes even when these are purely external. Such management behaviour could result from an ethical commitment to valuing the environment *per se* (Etzioni 1988) and/or a market structure, which relax the constraint on firms to maximise profits and therefore allow the pursuit of a wider range of management goals (Williamson 1963). Alternatively the adoption of clean technology leads to improved profitability. Given that most firms are probably not profit maximisers and work within conditions of uncertainty a large part of company behaviour is probably governed by habit and rules (Simon 1962). Such rules of thumb and practices represent the culture of the company. The significance of the role of top management is important and an understanding of how they become convinced to choose cleaner technologies given the competitive position of the enterprise is crucial (O'Connor 1997).

Negative cultural influences on the take up of clean technology include a fear of change following the introduction of new technologies and the new organisational patterns which may arise (Christie et al. 1990). Further barriers are management inertia and a lack of internal communication (OECD 1995), and concerns among workers and unions with job losses (Smith 1977); although there is a lack of evidence of such job losses (OECD 1992a). There is conservatism and established practice in that most firms address specific pollution issues rather than strategically implementing clean technology investments to create a source of competitive advantage, i.e. for most firms their environmental policy is driven more by threat than opportunity (Newman et al. 1992).

It has been argued that of key importance in the achievement of sustainable business activity is a shift in management thinking, values and practice (O'Riordan 1985; Stead and Stead 1992; Roome 1994) so that the environment is placed high on the business agenda and environmental concerns are integrated into corporate culture (Winter and Ledgerwood 1994). In particular there is a need for top management support especially among SMEs (Hutchinson and Chaston 1994; Winter and Ledgerwood 1994; Christie et al. 1995; OECD 1985, 1987; Schmidheiny 1992) and, in addition, for that management to base its decisions on appropriate information (e.g. eco-audits, life cycle analyses) and accounting practices (Yakowitz 1991).

(iii) The influence of information and advisory sources

Imperfect information is inherent to the process of technological change and markets for information are notorious for being imperfect (Arrow 1962). In addition, the skill and know how of management and the labour force in SMEs is variable. It is therefore hypothesised that there is a need for knowledge and understanding (OECD 1987; Christie et al. 1995; BCC 1994; Staudenmaier 1985, Winter and Ledgerwood 1994) and independent advice (OECD 1987).

Moreover, economic theory suggests that the dissemination of information about new technology is likely to be a critical determinant of diffusion (Stoneman 1983). Information and advisory sources include: trade associations, universities, R&D organisations, official government sources, business to business networks, environmental consultants, help and advice from suppliers and customers. External company networks and information sources are critical for the firm to understand and respond to difficult problems such as environmental pressures (Pasquero 1991) and to guide company strategy, operations and R&D (Roome 1994). In fact, it has become increasingly recognised that business services, in particular, play a strategic role in enabling firms to achieve competitiveness by affecting adjustment to products, processes, skills, organisation and management in response to social, economic, institutional and legal pressures (Bailly 1987; Gillis 1987; Marshall 1988; Illeris 1989; Coffey and Polese 1989; Martinelli 1991; Perry 1991; Marshall and Wood 1992).

1.4 Other Hypotheses Considered

(iv) Modern machinery can embody good environmental performance

The age of the plant and machinery in each firm is likely to impact on environmental outcomes, costs of compliance and the number of clean technology initiatives. Broadly speaking, it could be anticipated that the more up-to-date equipment will embody the best environmental technology. The status quo is maintained when industrial facilities are old and capital turnover is low (Hartje and Lurie 1985). However, having such up-to-date relatively clean machinery could also mean that such a company did not require as many clean technology initiatives as a counterpart trying to come to terms with the implications of older and dirtier machinery.

(v) Skills will foster initiatives

Firms with an abundance of skills will undertake more initiatives to reduce environmental pollution. These firms are often more engaged in R&D and are likely to find ways to reduce pollution and introduce clean technologies (including through incremental innovation). The presence of skills is important, though it is also important to recognise that some clean technologies and innovation requirements, to

deal with environmental effects, may need skills different from those necessary for the firm to compete in its usual line of business.

(vi) R&D will enable firms to take up technologies

The R&D activity of the firm is expected to play a critical role in the adoption and development of clean technologies and, because of its relationship with competitiveness, R&D is also seen as the means through which business develops environmentally benign products and processes (Kodama 1991; Christie et al. 1995; OECD 1995; Irwin and Hooper 1992; Roome 1994).

(vii) National regulation and grants foster environmental performance

Environmental initiatives are also hypothesised to be related to the stringency of environmental standards, levels of enforcement and environmental costs, and the relative importance of other drivers faced by the firm. Grants and subsidies are expected to raise the take up of clean technologies. The investigation undertaken here, by including firms at an EU-level (across a range of countries/regions), involves a variety of regulatory climates, costs and other drivers.

1.5 Important Constraints

Numerous impediments to the adoption of clean technologies have been identified and are discussed in OECD publications (1985, 1987, 1990, 1991, 1992a, 1992b, 1995) and other studies (Meller 1986; Commission of the European Communities 1983, 1984; PA Consulting Group 1991; ACOST 1992; Medhurst 1994).

1.5.1 Capital stock

Usually clean technologies (CTs) are more likely to be less costly in new plants than in old plants that require retrofitting to install this technology. In addition, an OECD study (1987) that was based on extensive interviews with industry shows that technical innovations are easier to achieve in industries in their investment renewal or modernisation phase. Moreover opportunities for investment in cleaner technologies are reduced where industry and firm growth rates are slow. Capital assets depreciation impedes changes in production processes. Existing equipment is rarely replaced if it has not been written off or if it has not reached the end of its useful life; which may substantially exceed a plant's depreciation period. This rigidity arises since most companies regard exiting equipment as a sunk cost and may continue to be beneficial even after the depreciation period is completed. Furthermore, CTs are sometimes more difficult to set up due to the specific characteristics required by each plant or company for their production process. This also

hinders reselling ageing equipment once a more profitable replacement is on sale[3] (Hartje and Lurie 1985).

1.5.2 Clean Technologies vs. End-of-Pipe Technologies

Plant specific economics usually favour the introduction of End-of-Pipe (EOP) technologies for the following reasons.

- Cost advantage: EOP does not affect investments already in place.
- Risk averse: EOP techniques provide tested certainty regarding their efficiency. This risk averse attitude is very pronounced among SMEs.
- Emission specific regulatory rigidities may in effect require EOP technologies.
- Market pressure: capital markets along with banks or other lenders are often pushing forward conflicting demands (i.e. high rates of return while maintaining a good environmental profile). Therefore, it is often the case that companies tend to choose, after a shortsighted cost-benefit calculation, techniques that have the least cost and maximum benefit short term while overlooking cleaner and more profitable options that might have a longer payback period.
- Ratchet effect: the introduction of EOP limits the risk of regulations and standards being tightened up in the short to medium term.

1.5.3 Product quality

Changes to cleaner production techniques can affect quality and have repercussions downstream. Changing material inputs from more to less toxic substances, for example, necessitates careful consideration of how such changes will affect equipment performance and final product quality. In the same vein, product redesign may require equipment modifications within a process line.

1.5.4 Accounting obstacles

Access to satisfactory technical and management information is important. There may be difficulties in evaluating the profitability of environmental investments. Accurate costing involves the capabilities and data sources of a number of personnel including the materials manager, the production engineer, or the financial officer. Contributions from multiple, rather than, single departments will be necessary to assemble such data (White et al. 1992, 1995). Failure to accurately quantify benefits and costs could bias investment decisions against pollution prevention. Moreover, popular investment appraisal and accounting conventions, e.g. the sim-

[3] Innovation of new and more productive processes usually outpaces adoption capacity by industry.

ple pay back criterion, can argue against the adoption of cleaner technologies by obscuring their profitability (White and Becker 1991).

1.5.5 Capital rationing

Projects are desirable (profit-maximising) only if they have positive Net Present Values (NPVs). The cost of capital is the cost of not spending the $100 on something else. In fact, the most desirable projects are those that provide the highest NPV per dollar invested (Dixit and Pindyck 1994). Firms often set limits on the capital available to individual business units. This places a ceiling on funds available for new investment and forces managers to prioritise across projects, all of which may have positive NPVs (Antle and Eppen 1985).

1.5.6 Risk

There may be risk attached to the investment especially with novel technologies as distinct from known technologies. There may be a fear of a change to regulations and standards; supply side features of the pollution control industry are important, including speed of innovation (availability of clean technologies) and market constraints, tensions in favour of proven "conventional" processes (i.e. established technology versus novel solutions) and constraints arising from any inadequacy in the development of markets, e.g. for recovered or recycled products. Hence, if the project in question is riskier than the firm's business generally, the cost of capital will be higher, because riskier investments demand a higher return. There are difficulties in determining investments that are "risk-equivalent" which contributes to making the task subjective (Commoner 1994).

1.5.7 Other issues

Cleaner technologies are associated with certain contingent benefits, which are difficult to predict and quantify. Thus, incorporating the future monetary benefits of such an investment into a project profitability analysis is problematic. The monetary benefits depend on if, when, and how much liability cost is avoided (White and Becker 1991). Cleaner technology profits may materialise well beyond a certain time frame commonly applied in investment analyses. Analytical methods, which fail to capture this future stream of savings, contain inherent biases against cleaner technology investments. In the competition for limited capital resources, such investments are likely to be rendered non-competitive hence more traditional pollution control projects and projects that are primarily driven by non-environmental objectives are undertaken.

1.6 Technology Diffusion

Though not all the evidence on technology diffusion is conclusive, there is broad agreement on two points. First, new technologies are never adopted by all potential users at the same time. The widespread diffusion of new technologies can take anywhere from five to fifty years. Second, countless studies have confirmed that the diffusion of new technologies follows a predictable inter-temporal pattern i.e. technologies are adopted rather slowly at first, then more rapidly, and then slowly again as a technology specific "adoption ceiling" is reached. These stylised facts have prompted researchers to focus on two related questions: Why do some firms adopt a given innovation before others? Why do some innovations diffuse more quickly than others? (see Blackman and Bannister (1996) for an extensive analysis). Researchers have found that new technologies are adopted fastest by firms that are:

- large,
- have well-trained staff,
- incur high regulatory costs when using an existing technology,
- have infrastructure complementary to the new technology,
- are in fast-growing industries,
- invest more in R&D,
- pay relatively low prices for inputs used intensively by the new technology,
- have relatively old existing capital.

Despite considerable research, the evidence regarding the impact of market structure, the degree to which the market is competitive or controlled by a small number of firms and the timing of diffusion is inconclusive. Moreover, even if clean technologies have significantly lower production costs, diffusion will not be immediate. To this end, all firms will not necessarily rapidly adopt CTs simply because, in most cases, they reduce production costs. A broad range of firm-level, sector-level, and country-level characteristics determine whether or not and how quickly new technologies are adopted, and there are likely to be systematic differences between them in nearly all of these characteristics.

1.7 Research Outcomes

The research is aimed at policy makers at both the national and EU level as they attempt to devise policies that would enable the achievement of both competitiveness and environmental targets (and, to minimise the negative trade-offs between the two and perhaps even exploit any positive links between these goals). More particularly, while designing the research, the two anticipated benefits were:

- increased focus of both industrial and environmental policy instruments to improve their effectiveness and efficiency in achieving goals like "sustainability" and a higher "employment intensity" of growth and,

- better integration of industrial/regional policy at the national and EU levels with environmental policy (Commission of the European Communities 1993).

The research is relevant to Agenda 21 especially in the recognition that government alone cannot achieve the underlying principles. The commitment of relevant groups and people is necessary in order to bring about the objective of an integration of sustainability and growth. The fifth Community Action Programme of policy and action in relation to the environment and sustainable development also recognises that the road to sustainable development requires changes in behaviour in the business world and at the level of the ordinary citizen. The importance of information, education and training is stressed throughout the programme (De Marchi 1995).

1.8 Book Structure

The methodology and variables considered are described in Chap. 2. Chapter 3 provides a background to the three industrial sectors considered: furniture, textile finishing and fruit and vegetable processing. Chapters 4, 5 and 6 discuss the results of the research for each industrial sector. Chapters 7 and 8 consider the importance of external sources of advice and company culture respectively. Chapter 9 presents the conclusions and policy recommendations.

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