What Makes Companies Green?
Organizational and Geographic Factors in the Adoption of Environmental Practices

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ABSTRACT: This paper advances the hypothesis that organizational factors play a key role in the adoption of environmental innovations, referred to as environmentally conscious manufacturing (ECM) practices. We distinguish among three classes of organizational factors: organizational resources, organizational innovativeness, and organizational monitoring systems. The research also explored the interplay of organizational factors and spatial or geographic factors (such as proximity to customers and suppliers) in the adoption of ECM practices. A structured field research design, involving "matched pairs" of plants, was employed to address these issues. The findings confirm the hypothesis. Organizational factors matter significantly in the process of ECM adoption. Furthermore, two classes of organizational factors are particularly significant to ECM adoption: organizational resources and organizational monitoring systems. Organizational monitoring systems composed of quantitative goals and related metrics are found to be a key factor in ECM adoption. The research finds that geographic or spatial factors have little effect on the adoption of ECM practices. This reflects the significant geographic distance between customers and suppliers in the sample. There may be reason to expect that geographic factors play a more significant role, and this is a subject for future research.

Key Words: environmental innovation, organizational capabilities, environmentally conscious manufacturing

INTRODUCTION

The adoption of innovative environmental practices by industry is a subject of considerable interest to economic and environmental geographers as well as by social scientists concerned with the environment from a variety of disciplines. Environmental innovations are a special class of advanced manufacturing practices, referred to here as environmentally conscious manufacturing (ECM), which include practices such as source reduction, recycling, pollution prevention, and green product design. A number of studies have noted the adoption of ECM practices by industry [Florida 1996; Porter and Van der Linde 1995a, 1995b; Denton 1994; Office of Technology Assessment 1994; Makower 1993; North 1992; Office of Technology Assessment 1992; Schmidheiny 1992; Smart 1992], while others have examined the factors associated with adoption of these practices [Florida 1996; Atlas and Florida 1997]. A growing body of research argues that adoption of ECM practices can lead to improvements both in environmental outcomes and overall business performance [Porter and Van der Linde 1995a, 1995b; Hart and Ahuja 1996]. This literature, however, is dominated by case studies that provide suggestive insights but from which is it is difficult to generalize. Furthermore, these studies tend to focus on the role of factors operating outside the boundaries of the firm, such as regulatory pressure or market forces, in motivating firms to adopt environmental innovations.

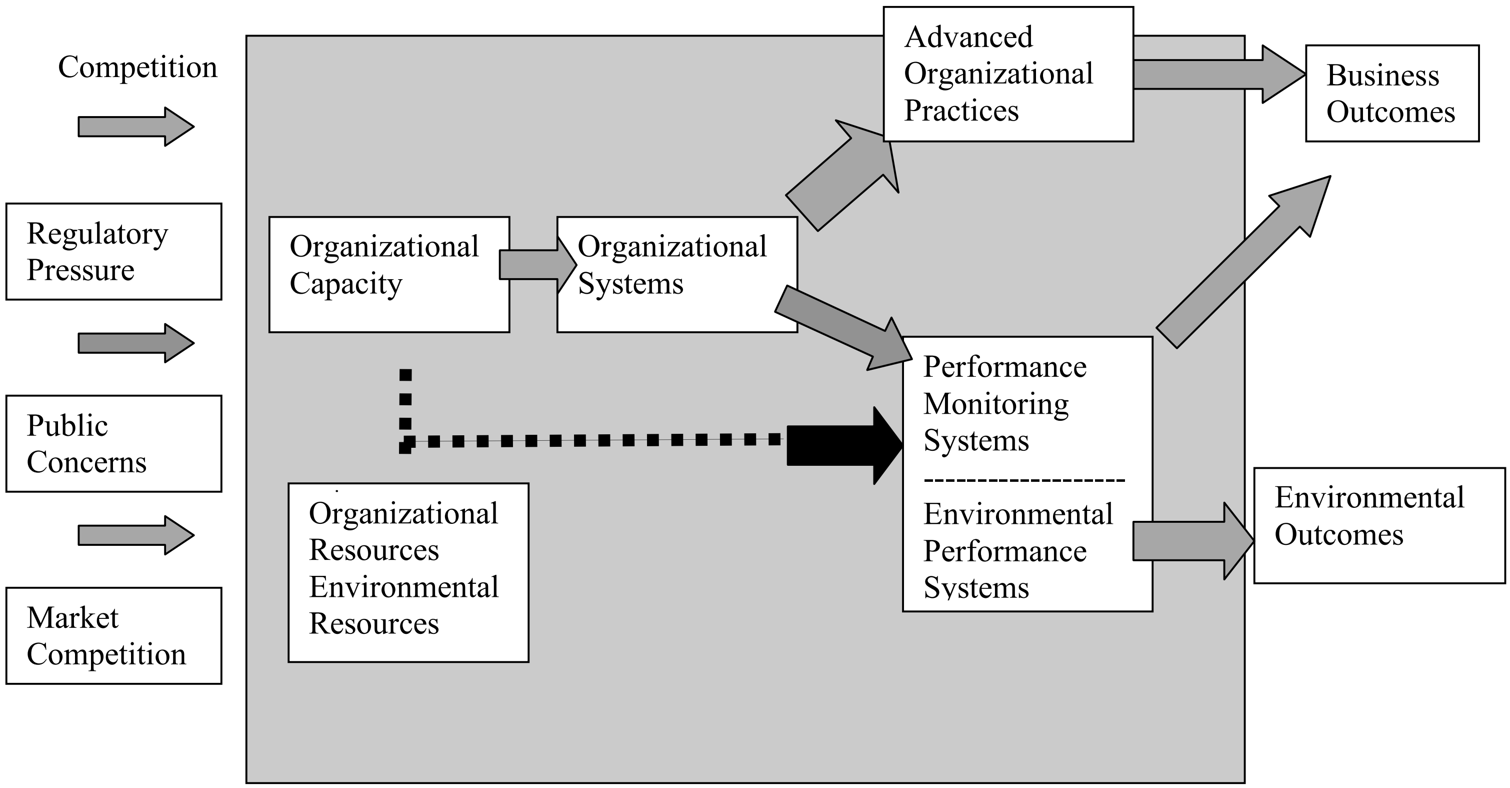
Geographers have shown considerable interest in the adoption and diffusion of advanced manufacturing practices. There is a general consensus in the literature that the adoption and diffusion of such practices is facilitated and enhanced by close geographic proximity, clustering, agglomerations, and tight linkage between customers and suppliers across the chain of production [von Hippel 1988; Piore and Sabel 1984; Porter 1998, 2000; Angel 1994, 1995; Cooke and Morgan 1998]. Recent research [Theyel 2000] has probed the connection between organizational and geographic factors in the adoption of ECM-like practices among plants in the chemical industry. This research finds that geographic factors play, at best, a limited role in the adoption of these advanced environmental practices – a finding that stands in stark contrast to the significant role played by geographic factors in other studies of advanced environmental practices.

Little, if any, empirical research has examined the way that factors operating inside the firm – organizational factors – affect the propensity to adopt ECM practices. Such factors are important, as both organizational theory and recent empirical research on the adoption of advanced business practices indicate that organizational factors matter significantly in the adoption of organizational innovations by firms. Recent studies focus on the role of "organizational capabilities" in both organizational innovation and organizational performance [Cohen and Levinthal 1994; Teece and Pisano 1994; Winter 1987]. This work suggests that organizations vary in their internal resource bases and procedures, which in turn affects their ability and opportunity to respond to internal and external challenges.

Building from this emergent literature on organizational capabilities, this paper focuses on the organizational factors associated with the adoption of ECM practices. It advances the hypothesis that organizational capabilities matter significantly in the adoption of ECM practices. In advancing this hypothesis, we distinguish between several dimensions of organizational capabilities: organizational resources and capacity, organizational innovativeness, and organizational monitoring. Organizational resources and capacity refer to the level of overall level of resources and specialized environmental resources and capacities possessed by firms. Organizational innovativeness refers to firms' previous commitment and track record in implementing advanced organizational practices. Organizational monitoring refers to the methods by which organizations measure, analyze, and monitor their performance in key dimensions (in this case environmental performance and its relationship to overall business performance). We also examine the role of geographic proximity (in particular, the linkage between customers and suppliers across the production chain) in the adoption of ECM practices.

The research was designed both to assess the relative roles played by organizational factors in the adoption of ECM innovations, to examine the interplay of organizational and geographic factors, and to zero in on the functions of various dimensions of organizational capabilities in this process. To help structure our argument, a model of the interactions among these factors is presented in Figure 1. The model outlines the system of relationships between external (market and regulatory) factors and several dimensions of organizational capabilities. While much research in this area has explored the role of regulatory pressure and market competition on environmental outcomes, we focus on the role played by organizational factors in affecting the adoption of advanced environmental practices.

Figure 1: Model of Organizational Factors, Organizational Systems, & Outcomes



Source: by authors

We explore these questions and hypotheses through a structured field research study of a sample of manufacturing organizations. The research was designed as a quasi-experiment and is based upon "matched pairs" of plants in several industries. Field research was conducted at 11 plants and consisted of more than 100 personal interviews.

The major findings of the research confirm the main hypothesis. The findings demonstrate that organizational factors matter significantly in the process of ECM adoption. We find that organizational capabilities play a considerable role in ECM adoption by sample plants. Furthermore, the research results indicate that two types of organizational factors are significant to ECM adoption.

First, organizational resources – particularly specialized environmental resources – provide the embedded capacity that enable sample plants to respond to external stimuli and implement environmental innovations. In effect, organizational resources create the opportunity space from which individual managers and work groups are able to experiment with and effectively implement ECM practices. Interestingly, the findings suggest a loose association between organizational innovativeness (measured as prior adoption of advanced business practices) and ECM adoption among sample plants.

Second, the findings indicate that organizational monitoring systems play a crucial role in ECM adoption. The findings here suggest that in order for environmental gains to be realized, explicit objectives and monitoring systems are required to assess the relationship between dedicated organizational resources, innovative practices, and environmental and business impacts.

Third, the findings indicate that geographic factors play at best a limited role in the adoption of ECM practices. Some diffusion of ECM practices occurs across the production chain, but it does not appear to be substantial. This diffusion process appears to be inhibited by the significant geographic distance between customer plants and their suppliers. This is in line with the findings of Theyel [2000] and others. This result may reflect particular characteristics of the field research sample. The establishments in the sample generally were characterized by globally distributed, as opposed to spatially concentrated, supply chains. There is reason to expect that geographic factors may play a role in the adoption of ECM practices in more geographically concentrated industries.

THEORY, CONCEPTS AND HYPOTHESES

Our main hypothesis, as noted above, is that internal organizational factors play a fundamental role in the ability of organizations to adopt advanced environmental practices. To better inform this conceptualization, we draw on four strands of recent research. First, we briefly review previous research on role of factors such as regulatory pressure and/or market forces in shaping the adoption of advanced environmental practices. Second, we turn to recent studies of organizational factors in the adoption of advanced organizational practices (particularly innovative workplace practices) and related research on the role of "organizational capabilities" on firm performance. Third, we review recent literature on the role of organizational factors in the adoption of advanced environmental practices. Fourth, we review recent literature on the effect of geographic factors on the adoption of advanced manufacturing practices in general and ECM in particular. We believe our conceptual approach offers a more synthetic perspective on what matters to the adoption of environmental practices in particular, and some general insights into the role of organizational factors in the adoption of advanced organizational practices more generally.

Adoption of environmental innovations: A growing body of studies notes the adoption of environmentally conscious manufacturing (ECM) practices by industry [Florida 1996; Porter and Van der Linde 1995a, 1995b; Denton 1994; Office of Technology Assessment 1994; Makower 1993; North 1992; Office of Technology Assessment 1992; Schmidheiny 1992; Smart 1992]. This work has reinforced a significant shift in theorizing about the relationship between economic and environmental performance. Traditionally, the relationship between the economy and the environment was thought of in terms of a rather stark tradeoff. But, recent theorizing and some empirical research have questioned this view, suggesting that adoption of environmental innovations enable firms to overcome this dichotomy. A number of studies have argued that corporate efforts to implement ECM practices are part of broader strategies to improve overall business performance as well as environmental outcomes. One influential argument, associated principally with Porter [1991], contends that the pressure to innovate stems from regulatory pressure, as firms respond in creative and dynamic ways to environmental regulation by introducing innovations that improve environmental outcomes.

Other studies argue that environmental innovation is the result of market pressures that cause firms to become more efficient. These studies are important because they have shifted attention away from simple regulatory compliance and toward factors that contribute to environmental innovation. Several studies note that practices that improve facilities' overall efficiency can be applied to environmental management to reduce the toxicity and/or amount of wastes generated, thereby lowering the environmental risks resulting from production operation. A study by Porter and van der Linde [1995a, 1995b] concluded that firms respond to competitive conditions and regulatory pressure by developing strategies to maximize resource productivity through efforts to enhance their "resource productivity," enabling them to simultaneously improve their industrial and environmental performance [1995a]. A statistical study by Hart and Ahujba [1994] found that efforts to prevent pollution and reduce emissions had a positive effect on industrial performance. This study also found that the biggest benefits accrued to large polluters, noting that the closer a firm came to zero emissions the more expensive it was to further reduce pollution or realize efficiency or performance gains.

This body of research is important in that it has helped recast the debate over environmental and business outcomes and began to focus attention on the adoption of environmental innovations. However, this work suffers from two general kinds of problems.

One the one hand, virtually all of it has neglected the potential role played by organizational factors operating inside firms. On the other hand, the great majority of studies take the form of selective case studies, which represent "success stories," thus leaving the external validity of results open to question.

Organizational innovation: There is a long and distinguished literature on the adoption of organizational innovations and that factors associated with adoption of innovative practices. For our purposes here, it is useful to focus on recent theorizing on the role of organizational capabilities in shaping firm performance. These studies take issue with traditional economic approaches and argue that firms possess different bundles of organizational capabilities that can lead to differential performance.

There is a considerable literature on the recent adoption of organizational innovations by firms. These organizational innovations are sometimes referred to under rubrics such as "lean production," "agile manufacturing," and "high-performance work systems" [see for example Womack, Jones and Roos 1990; Osterman 1994]. According to this perspective, organizational innovations are conceived as interrelated bundles of systems of practices (e.g. self-directed work teams, worker rotation, total quality management, and continuous process improvement). Osterman [1994] found a significant rate of adoption of innovative workplace practices across a wide sample of U.S. business establishments. Other studies have examined the factors associated with the adoption and diffusion of such organizational innovations. Florida and Jenkins [1998; Jenkins and Florida 1998] found that the adoption of such organizational practices by a sample of Japanese-owned manufacturing "transplants" in the United States was associated with factors such as capital intensity and in industries that are distinguished by tight end-user supplier relations. Several significant studies have probed the relationship between innovative practices and firm performance. MacDuffie [1994] identified performance gains associated with adoption of lean production in a large international sample of automotive assembly plants, while Ichniowski, Shaw, and Prennushi [1993] found significant performance gains associated with the adoption of a bundle of innovative manufacturing and work organization practices in the steel finishing sector.

These studies provide a window into the role of organizational capabilities in the adoption of innovative practices and in assessing their effect on organizational performance. Our research applies insights culled from this work to examine how organizational factors effect the adoption of innovative ECM practices.

Organizational factors and the adoption of advanced environmental practices: There is a growing literature on the adoption of environmental innovations by firms and the factors associated with such adoption. Such advanced practices include source reduction, recycling, pollution prevention, and green product design. This is clearly a heterogeneous group of business practices, which may have a heterogeneous set of drivers for their adoption. Recent studies note the relevance of organizational factors to the adoption of environmental innovations [Apaiwongse 1995; Georg, Ropke and Jorgensen 1992; Gladwin 1992; Green, McMeekin and Irwin 1994; Groenewegen and Vergragt 1991; Kemp, Olsthoorn, Oosterhuis and Verbruggen 1992; Lawrence and Morell 1995; Post and Altman 1992; Schot 1992; Winn 1995; Winn and Roome 1993]. Some studies note similarities in the factors associated with the adoption of environmental innovations and advanced organizational systems and practices. A Massachusetts Institute of Technology study of several automotive factories identified a relationship between innovative production practices and ECM adoption [Maxwell, Rothenberg and Schenck 1993]. Another study found that organizations with a “team-orientation” were more likely to voluntarily adopt environmentally beneficial policies [Apaiwongse 1995]. A field research study of U.S. chemical companies concluded that higher performing environmental companies tended to have explicit objectives, long-range planning, performance-based evaluations, pro-active corporate cultures, formalized control, measurement and reward programs [Dillon and Fischer 1992]. A 1994 Carnegie Mellon University survey examined the factors associated with ECM adoption through survey research on national sample of U.S. corporations [Florida 1996]. The CMU study found that nearly half of survey respondents had implemented a "total quality environmental management system," similar to the total quality management programs used more general in manufacturing settings. Nearly two-thirds of survey respondents reported that line workers were key contributors to pollution prevention efforts – the same type of worker involvement that distinguished advanced manufacturing systems more generally. A survey research study [Atlas and Florida 1997] found that organizational factors play an important role in the adoption of green design.

Other studies note an association between ECM adoption and supply chain innovations of the sort that characterize advanced production systems [Geffen and Rothenberg 2000; Hall 2000]. A Danish study [George, Ropke Jorgensen 1992] found that the adoption of pollution prevention was associated with tight linkages and interactions across the chain of production – that is among plants, their suppliers and customers – a finding which is in line with the findings of research on the adoption of advanced production systems [esp. Florida and Jenkins 1998; Jenkins and Florida 1998]. A Dutch study [Schot 1992] of multinational corporations also found that interactions with suppliers, as well as just-in-time inventories, were key factors in the adoption of environmental innovations. A survey of British companies [Green, McMeekin and Irwin 1994] found that the most important requirements for projects resulting in environmentally friendly products were collaboration with customers and suppliers that the quality of interaction processes between plants, suppliers and customers. The CMU survey found that half of survey respondents identified suppliers as key contributors to pollution prevention efforts [Florida 1996].

Geographic factors: There is a large and extensive amount of literature on the effect of geographic factors on the adoption of advanced manufacturing practices [von Hippel 1988; Piore and Sabel 1984; Porter 1998, 2000; Angel 1994, 1995; Cooke and Morgan 1998]. Generally speaking, this literature finds that geographic factors, such as spatial clustering and close proximity between customers and suppliers, facilitate the adoption of advanced manufacturing practices.

There is considerably less research on the effects of geographic factors on the adoption of ECM practices. Theyel [2000] examined the role of economic, organizational, and geographic factors in the adoption of ECM practices by manufacturing plants in the chemical industry. This research was based on a large sample of facilities and included both systematic survey research along with field research and interviews of a sub-sample of plants. Theyel found that organizational factors played a much more significant role in the adoption of advanced environmental practices than did geographic factors. While the research did show that supplier chains and industrial networks can affect the adoption of ECM practices, geographic proximity was not a factor. In fact, this research attributes virtually no role to factors such as geographic clustering or agglomeration in the adoption of ECM practices.

RESEARCH DESIGN

Building from these three strands of literature, we advance the hypothesis that organizational factors play a significant role in the adoption of environmental innovations. We pose this hypothesis in contradistinction to the prevailing view in the literature – and to some degree in both the conventional wisdom and prevailing approaches to public policy – which emphasizes the role of regulatory factors and market forces in motivating ECM adoption. We draw from the literature on organizational capabilities to inform our perspective. Specifically, we argue that internal organizational capabilities play a large and significant role in the adoption of environmental innovations in particular (and in the more general process of organizational innovation broadly construed). We distinguish among three dimensions of organizational capabilities: organizational resources, organizational innovativeness, and organizational monitoring.

A structured field research design was developed to test these hypotheses and shed light on the factors associated with ECM adoption. Before proceeding to a detailed description of the field research, it is useful to highlight the key principles underlying our methodology. The research design took into account recent advances in the design of field research or qualitative research [King, Keohane and Verba 1994]. In the past, qualitative research in the social sciences has been subject to criticism on the grounds of external validity. The basic line of criticism contends that such research suffers from small sample sizes, which are biased and thus generate findings from which it is hard to generalize. While such criticisms are valid to some degree, they tend to conflate small sample sizes with inadequate sampling procedures and sample selection. A great deal of qualitative research in the social sciences suffers not from small sample sizes per se, but from problematic sample selection (e.g., "success stories" or convenience and snow-ball sampling). Recent advances in sample selection techniques make it possible to structure qualitative research designs in ways that generate samples that are much more reliable and thus generate externally valid findings.

Sample design and selection: The objective of the research was to better understand the processes, by which some organizations adopt environmental innovations, while others do not. We thus designed the sample along the lines of a quasi-experimental design, with ECM practices constituting the intervention to be examined. We selected matched pairs of plants composed of high- and non-adopters of ECM practices. The high-adopters represent the experimental group, while the non- adopters represent the control group. Some might criticize this approach as sampling on the dependent variable. Recall however that qualitative research is time and resource intensive and that sample sizes are small. Focussing on a randomly distributed sample would in all likelihood overlook organizations at the extremes of the distribution – that is, organizations that represent a considerable degree of the variance in the population. Our strategy was to try to recreate this variance in our sample. Furthermore, guiding our sampling strategy was the belief that real analytical leverage could be gained into organizational factors by focussing on organizations at the extremes of the distribution – those with a special propensity to adopt ECM practices and those with a special propensity to ignore them. By focussing on organizations at the ends of the spectrum of adoption, we sought to be better able to assess what factors facilitated or obstructed ECM adoption. In order to control for the effects of industry (technology and process differences) on ECM adoption, we selected matched pairs of plants in several types of industries where different patterns of adoption and different environmental might be expected: process industries, complex assembly industries, and fabrication industries.

Within these constraints, we also sought to obtain a diverse sample of plants with respect to size and geographical location.

We used several techniques to identify matched pairs of sample plants. First, we used available data from the U.S. Environmental Protection Agency to identify ECM adopters. Here, we used the EPA "Envirosense" database that includes information on pollution prevention and other ECM practices. A search of this database identified 184 plants with high-observed ECM adoption. We also sought to focus our research on plants that utilized ECM practices to relatively address waste streams and emissions. To do so, we examined EPA data on environmental outcomes for the 184 plants. This included EPA data on hazardous waste generation (from the EPA's Biennial Reporting System – BRS) and on toxic releases (from the EPA's Toxic Release Inventory – TRI). Of the total 184 plants, 114 were identified in the BRS data and 36 were identified in the TRI data. These 150 surviving plants were then separated into groups in the same industries, assigned on the basis of four digit SIC code. Each plant was rated on the extent of ECM adoption and BRS and TRI data on source reduction and recycling. We excluded plants with relatively small amounts of wastes or chemicals. EPA data were checked to ensure that these facilities had not reported in engaging in pollution prevention activities.

This process identified potential matched pairs of plants in the following industries: industrial organic chemicals (SIC 2869), electroplating (SIC 3471), automotive parts (SIC 3714), aircraft parts (SIC 3728), turbines (SIC 3511), and high speed drives and gears (SIC 3566). The procedure ultimately yielded a sampling frame of 17 plants from which we sought to identify four matched pairs of plants (n=8). We contacted the 17 plants and 11 agreed to participate in the study. It was decided to include all 11 plants in the study. The sample included 3 plants in the aircraft industry (two high-adopters and one non-adopter), three plants in the chemical industry (two high-adopters and one non-adopter), two plants in the electroplating industry (a high- and a non-adopter), and three other plants (two high-adopters and a non-adopter). The geographic distribution of sample plants was as follows: California (n=3), Alabama (n=2), Louisiana (n=2), Connecticut, Michigan, Pennsylvania and Texas (n=1, each).

Field research: Field research consisting of one or two day site visits and personal interviews were conducted with the 11 sample plants. The field research collected detailed information on the role of organizational factors in ECM adoption. The site visits and interviews obtained data on factors such as organizational characteristics and resources, business and management practices, environmental management practices, performance monitoring systems, and environmental and business outcomes, as well as regulatory compliance, market and competitive conditions and other external factors. More than 100 personal interviews were conducted with plant managers, production operations, environmental staff, financial affairs, supply and procurement, human resource representatives and production workers. A structured field research instrument was developed for conducting interviews for each of these groups of informants. Detailed notes were taken and each of the field research visits was written up as a case study (For a fuller description of the research design, copies of the research instruments and summaries of the field research for each facility, see Florida and Atlas 1997).

To gain deeper insight into the process of ECM adoption, a rating or scoring system was developed for key variables and indicators, including: organizational resources, dedicated environmental resources, advanced business management practices, environmental monitoring systems and several other measures. The following specific measures were employed. These measures are derived from previous studies of the adoption of advanced manufacturing practices in general and ECM practices more specifically.

- **Organizational resources:** includes facility size (number of employees), company size (number of employees). This measure is designed to explore the effect of overall plant resources on the adoption of ECM practices. The underlying proposition here is that large establishments will have more resources to devote to their advanced practices in general and that this will enable them to more efficiently adopt specialized practices as well.
- **Environmental resources:** includes number, tenure, and experience of dedicated of environmental staff. This measure explores the effect of specialized environmental resources on ECM practices. The underlying proposition here is that establishments with specialized environmental resources will be able to focus attention, effort, and energy on the adoption of ECM practices.
- **Business practices:** includes ISO certification, mission statements, formalized quality management systems, just in time inventory control, cross-functional resources, and problem-solving teams. This measure examines a plant's previous experience with advanced manufacturing practices. It is based on the underlying proposition that a plant that has prior experience with advanced manufacturing practices will have an established capacity and track record that will enhance its ability to implement advanced ECM practices.
- **Environmental monitoring and systems:** includes quantified environmental goals and objectives, environmental performance monitoring systems, environmental cost identification, use of control processes, environmental inspections and environmental supplier audits. This measure examines a plant's use of systems to continuously monitor environmental outcomes and performance. The basic proposition is that systems will enable plants to better gauge the relationship between environmental manufacturing practices and environmental outcomes. This results in enhanced adoption of effective practices.

Recognizing that ECM practices are a heterogeneous group, the study took considerable care to distinguish the effects of different organizational factors on different types of practices.

To operationalize these measures, we ranked interview responses for these indicators on a 6 point scale where 5 equals the highest value, and 0 the lowest. These interval ratings were based on the direct responses to the field research questions asked by interviewers. The research team coded the findings of the interview questions on a regular and consistent basis. Follow-up questions and probing were used to limit inter-rater bias in responding to questions and to ensure reliability of results.

STUDY FINDINGS

We now report the research findings. Generally speaking, the findings support the hypothesis that organizational capabilities matter significantly in the adoption of ECM practices. To presage and orient the discussion which follows, the Appendix presents the overall scores and for the major variables in the analysis.

As these data show, the findings are robust with plants in the high-adopter sample scoring considerably higher overall in terms of each organizational factor than plants in the non-adopter sample. The average overall score for high-adopter plants was 3.88 compared to 2.88 for non-adopter plants. Much the same pattern holds for three of the four major organizational factors in the analysis: organizational resources, environmental resources, and environmental performance and monitoring systems. In each of these categories, there is a difference in the scores for the two groups of plants. The fact that so many of these factors produced differences in response between adopters and non-adopters shows that organizational factors do indeed play a role in ECM adoption. The responses for advanced business practices were virtually identical for high- and non-adopters; this variable appears to have virtually no role in ECM adoption by sample plants. The following sections elaborate on these findings, by providing a detailed discussion of the field research findings in each of these categories.

TABLE 1. Organizational Factor Scores for Sample Plants

FACTOR	High-Adopters (N=7)	Non-Adopters (N=4)
Organization Resources	4.43	2.25
Environmental Resources	4.62	2.25
Advanced Business Practices	3.1	3.13
Advanced Business Practices (w/o ISO 9000)	3.4	2.75
Environmental Metrics and Monitoring Systems	3.37	1.5
Overall Score	3.88	3.28

Source: By authors

We focus on the role played by those organizational factors in ECM adoption. Here, we advance the hypothesis that organizational factors shape and motivate the processes by which organizations adopt advanced environmental practices. These organizational factors are the mechanisms by which firms respond – effectively or ineffectively – to stimuli originating in the external environment. In particular, we focus on the role of organizational capabilities. We examine several dimensions of organizational capabilities: organizational resources (including a specialized class of environmental resources), organizational innovativeness (measured as prior adoption of advanced business practices), and organizational monitoring systems (quantitative goals and measurement systems). We operationalize these measures based on the best and most systematic data that could be collected in the field research and on-site interviews. The subsequent sections present our key findings with regard to each of these factors.

Organizational resources: The first measure of organizational capacity is organizational resources. A central hypothesis is that organizational resources play an important role in ECM adoption. Organizations with greater resources possess the financial and human resources required to bear the costs associated with environmental and overall business improvement. To operationalize the construct of organizational capacity, we use measures of plant size, size of corporate parent, and size of environmental staff as well as a series of more qualitative measures. The data for sample plants on these dimensions of organizational capacity are presented at the top of the Appendix.

As these data show, organizational resources appear to be closely associated with ECM adoption. The overall score for high-adopter plants on this measure is 4.43 compared to 2.25 for non-adopters. This result appears to be driven by plant size, where there are substantial differences between high- and non- adopters; in contrast, the result for company size is not as varied. Thus, we find that ECM practices are related to plant size.

This point is reinforced by a closer look at the findings for individual plants. There is a clear resource differential between the two groups of plants. On the one hand, all but one of the plants (plant D) in the high-adopter sample are large plants, as measured by both plant and company size. On the other hand, all of the plants in the non-adopter sample (plant C) are small to medium-sized plants and only one is related to a large corporate parent. Furthermore, it important to point out that these two "outlier" plants have overall scores that deviate considerably from the other plants in their sub-samples. Specifically, the overall score for the one small facility/small company high adopter plant (plant D) is much lower (0.9) than that for the other plants in the high-adopter sample (average of 3.55). The overall score for the one plant in the non-adopter sample that is a division of a large company (plant C) is much higher (3.35) than the average for the non-adopter group (2.05). This reinforces the point that the level of organizational resources has a significant effect on ECM adoption.

The logic underpinning these findings regarding the relationship between organizational resources and ECM adoption can be elaborated as follows. Larger plants possess greater resources that can be devoted to environmental innovation. Smaller plants – particularly those that are subsidiaries of small companies – encounter greater resource constraints. In such cases, resources are more likely to be devoted to core business endeavors (such as "getting product out the door") leaving insufficient resources to adequately address environmental innovation. Consequently, these plants lag on this dimension.

The field research reveals that a variety of additional findings in terms of organizational resources. First, it appears that the relationship between corporate and plant level management can be important. The availability of corporate level resources may also play supportive role here. Looking at the field research results for individual plants we find that corporate level may affect the process of ECM adoption in two ways. On the one hand, we find that the explicit commitment of top corporate management ECM practices provides leverage and support for local managers to promote ECM adoption. On the other hand, we find that lack of support – and in particular failure of corporate level managers to provide requested assistance in developing and implement ECM practices – is a significant barrier to the adoption of environmental innovations at the plant level.

A caveat should be kept in mind when reviewing this data. Because of the use of the EPA Envirosense database in creating the initial 184-company sample, the study may over-report the significance of organizational resources in environmental innovation. Since the EPA database includes data on ECM practices, it may screen out companies that do not possess the organizational capacity necessary to be environmentally innovative. Thus, the initial sample may have over represented facilities with a high level of plant and/or corporate resources, and that over representation may affect the observed relationship between resources and innovation in the study findings.

Environmental resources: Environmental resources are a specialized form of organizational capacity. These comprise dedicated resources devoted to the environment. We operationalize environmental capacity as follows: size of environmental staff, tenure of environmental staff, and other related measures [see Appendix].

Generally speaking, we find that environmental resources play a significant role in the adoption of environmental innovations, as the data in Table 1 show. The overall score for high-adopter plants is 4.6 compared to an overall score of 2.25 for non-adopters. Furthermore, the results for all of the individual variables in this category of environmental resources are also greater for high-adopters than for non-adopters.

In addition to this, the field research data reveal several more specific findings. First, environmental staff appears to be positively associated with ECM adoption. The high-adopter plants had significantly larger environmental staffs than non-adopters. All of the high-adopter plants had dedicated environmental staff, ranging from several to nearly 50. High-adopter plants were also able to leverage significant environmental staffs of their corporate parents. In contrast, non-adopter plants had an average of roughly one dedicated environmental staff person and few, if any, corporate environmental resources to leverage.

Second, we find that tenure and experience of environmental staff are positively associated with ECM adoption. The average tenure for environmental managers in high-adopter plants was more than 10 years (with some plants averaging 20 years). The average tenure of environmental managers at non-adopter plants was significantly lower, ranging from 3 to 7 years with some managers working on a part-time basis.

Third, we find that individual managers can act in a proactive and innovative fashion to facilitate ECM adoption. Several plants reported that managers, particularly environmental managers, acted at times "on their own" to implement, champion, **and** spearhead adoption of innovative ECM practices. Organizational capacity provides a useful way to contextualize these individual actions and behaviors. Every organization possesses a distribution of individuals who can undertake innovative behaviors. Organizations with greater capacity – and in this case greater specialized environmental capacity – will possess more individuals who are likely to undertake innovative behaviors, thus increasing the probability that individual action will result in adoption of innovative practices. Furthermore, as we will see, ECM adoption is associated with explicit goals, objectives and measurements that act as additional motivating forces on individual behavior.

Taken together, these findings lead us to conclude that environmental capacity is important because of the specialized type of expertise or capability it mobilizes – the ability to formulate and implement environmental strategies. Access to human capital with specialized environmental expertise is important in identifying, implementing, and monitoring ECM practices. Due to the complexity of environmental law, such expertise is important in understanding the legal implications of possible changes and production process inputs and outputs. Furthermore, our findings indicate that environmental managers can act in a proactive way to facilitate adoption of environmental innovations, even in the initial or continued absence of noteworthy overall facility or corporate support.

Advanced business practices and ECM adoption: We now turn to the relationship between ECM adoption and the adoption of advanced business practices more generally. Previous research has pointed to an association between advanced business practices and the adoption of innovative ECM techniques. The reasoning here is straightforward: plants which adopt innovative business practices in general are more likely to be pre-disposed to adopting environmental innovations. The third section of the Appendix presents the relevant field research data for a range of advanced business practices, including total quality management, ISO 9000 certification, and just-in-time inventory control.

As these data show, there is at best a loose association between the adoption of advanced business practices and the adoption of ECM practices. There is virtually no difference in the overall score on this factor for high- and non-adopter plants. There is just one category – total quality management – where the result showed any non-trivial difference between high- and non-adopters. Interestingly, plants in the non-adopter group outscored plants in the high-adopter group in three of seven categories: ISO certification (5.0 versus 1.43), just-in-time inventory control (3.75 versus 3.29), and cross-functional work teams (3.25 versus 2.57). Particularly surprising was the finding for ISO 9000 certification, where the result is counter-intuitive. Only one high-adopter plant reported that it was ISO 9000 certified, compared to all plants in the non-adopter sample. Despite this, we observe a relatively high rate of adoption of advanced business practices across the entire sample, particularly for the two categories of work teams, just-in-time inventory control, and mission statements. While it is possible that the results here are anomalous and/or artifacts of our sample, we conclude that it is more likely that the mixed findings with regard to advanced business practices reflect the increasingly widespread adoption of at least some aspects of advanced business practices by U.S. manufacturing establishments.

ECM adoption on the shop floor: A considerable body of research on innovative work practices has focussed on the importance of involving shopfloor workers in work system innovations. A number of studies highlight the importance of production worker capabilities in both the adoption of and performance payback from innovative work practices. Careful empirical research on both the steel industry and the automotive industries have found that innovative work practices are most effective when they effectively mobilize the broad capabilities of production workers [Osterman 1994; Ichniowski, Shaw and Prennushi 1993; MacDuffie 1994; Florida and Jenkins 1998; Jenkins and Florida 1998].

The fieldwork yielded several interesting insights on the role of shopfloor workers in environmental innovation. First and foremost, plants across the entire sample reported the involvement of line workers to be of considerable importance to the adoption of ECM practices. A high-adopter plant reported that production workers are motivated to adopt ECM practices because the plant's team-based organization makes them responsible for environmental concerns in their area, such as noticing and reporting actual or potential chemical releases.

Second, plants across the entire sample reported that shopfloor workers are the source of many simple improvements, such as installing drip pans that cumulatively result in significant environmental gains. Sample plants reported that such improvements were obvious to line workers and that workers were frequently able to implement them. This was true of both high- and non-adopters. One high-adopter plant reported considerable gains in environmental performance as a result of such small scale, "common sense" improvements by production workers. The plant reported that such worker-initiated improvements accounted for some two-thirds of its environmental performance improvement. Another high-adopter reported that line workers developed a simple process for separating waste shavings from different metals, enabling the plant to sell these wastes at a greater return. A non-adopter plant indicated that "all" of its environmental innovations originated from production workers.

The field research data also indicate that workplace incentives play a significant role in this process. Sample plants reported that including environmental performance as part of workers' and facilities' overall performance evaluations tended to sensitize them to the benefits of engaging in environmental improvement. Sample plants also reported that line workers were more receptive to environmental requirements when the purposes behind them were made clear. Furthermore, the findings identified an interesting relationship between the adoption of ECM practices and worker-initiated environmental improvements. We found that sample plants that had adopted ECM practices were more likely to communicate their environmental objectives and progress to their workers. Plants in the sample reported the use of bulletin boards, newsletters, presentations, meetings and videos to communicate environmental objectives. All of the high-adopter plants utilized these forms of communication, while all but one of the non-adopter plants did not. Several high-adopter plants had formal policies on the environment and well-developed mechanisms to communicate those strategies to workers.

Organizational monitoring: Monitoring is a special type of organizational capability that refers to the ability of an organization to measure, assess, and track performance in key areas. To operationalize the construct of organizational monitoring, we collected data on what we refer to as environmental systems and monitoring – that is, the use of explicit environmental objectives, environmental performance monitoring systems, environmental costs identification, and internal environmental audits (see Appendix).

The findings here confirm that ECM adoption is closely associated with organizational monitoring. High-adopter plants outscored non-adopter plants by a score of 3.37 versus 1.5. Furthermore, this result appears to be driven by two or three key variables: environmental goals and objectives and environmental performance monitoring systems, and to a lesser degree by chemical control processes. The results for the four remaining variables are not very different: providing environmental information to workers, identification of environmental costs, environmental inspections and environmental audits of suppliers.

Further insight into this process can be obtained from looking at the field research findings in more detail. Here, a number of interesting findings emerge. First, the field research indicates that setting explicit quantitative goals for environmental improvement is closely associated with ECM adoption. Five of 6 high-adopter plants set explicit goals for waste and emission reduction, while only one non-adopter had done so. At two of these high-adopter plants, such goals were set at the corporate level and then implemented at the plant level.

Second, the field research demonstrates that the use of environmental performance systems for measuring progress toward goals is closely associated with ECM adoption. Environmental measurement systems appear to be an important tool for measuring results, determining progress, evaluating the effectiveness of alternative projects, motivating new initiatives, and identifying opportunities for ECM practices. One of the plants in the high-adopter sample developed systems to track environmental costs back to specific operations. This resulted, among other things, in increased sensitivity to pollution prevention opportunities. Many of the plants in the non-adopter sample simply included environmental costs in the general overhead category. Under such systems, environmental costs are allocated over all work through the common overhead rate, rather than being charged the particular operations or work that generated those costs.

A significant number of high-adopter plants reported utilizing systems to track chemicals and other materials. One high-adopter plant developed a system to track any spill or accident and to disseminate reports on them. While most of these events were trivial and did not have to be legally reported, the plant reported that the system functioned as a "learning device" and encouraged preventive measures. Another high-adopter plant reported that it records every environmental incident and conducts a root cause analysis. A third high-adopter plant reported that it developed a control system for all chemicals, requiring containers to be checked from centralized locations. This enabled the plant to closely track and monitor chemical use.

Third, the findings suggest that ECM adoption is associated with frequent internal inspections. High-adopter plants conducted frequent environmental inspections and were subjected to regular inspections by corporate environmental staff. Internal inspections were far less common at plants in the non-adopter sample.

GEOGRAPHIC FACTORS

Recent research, in particular by Theyel [2000], has examined the role geographic factors in the adoption of ECM practices by manufacturing plants. Theyel's research included both systematic survey research along with field research and interviews. Theyel found some evidence that ECM practices are adopted through supplier chains and industrial networks, but little evidence that geographic clustering affected the formation or function of these types of networks. In general, this research found that organizational factors may have a more significant role in the adoption of advanced environmental practices than geographic factors.

Our research found that some diffusion of ECM practices does occur up and down supplier chains, but that such diffusion does not appear to be substantial. All of the field research facilities' relationships with their customers and/or suppliers included processes by which information about ECM practices were exchanged or adherence to such practices was evaluated. While these facilities suggested ECM practices to their suppliers and vice versa, the extent to which suggested ECM practices actually flowed through these links was modest.

The reasons for this limited diffusion appear to be twofold. First, there was a somewhat sizable geographic distance between the field research facilities and most of their suppliers and customers. This distance made frequent on-site contact of the sort needed to encourage the sharing of ECM practices difficult. Second, it was not at all clear that the parties involved in these customer-supplier relationships were interested in engaging in extensive examinations of their suppliers and customers. Such examinations are often time-consuming and intrusive, and thus may be unappealing to many facilities. Thus, we find little evidence that geographic factors such as spatial clustering or agglomeration affect the adoption of ECM practices. This is in line with the findings of previous research [Theyel 2000], but it stands in contrast to other research that finds a positive relationship between geographic clustering and the adoption of other (non-environmental) innovations. It is worth pointing out, however, that this result may reflect characteristics of our sample. In light of this, we suggest that further research in the relationship between geographic factors and the adoption of advanced environmental practices is warranted.

CONCLUSIONS

This paper has examined the role of organizational factors in the adoption of environmentally innovations. We advanced the proposition that organizational capabilities matter significantly in the adoption of ECM practices. We distinguished among three dimensions of organizational capabilities: organizational resources and capacity, organizational innovativeness, and organizational monitoring.

Our findings by and large confirm the main hypothesis. We found that organizational factors matter significantly in the process of ECM adoption, suggesting that too much explanatory weight has been given to external factors in previous research on this subject. We further found that while external factors do play a role, they provide only a limited explanation for why firms adopt environmental innovations. Organizational capabilities both encourage and act as obstacles to the process of ECM adoption. Furthermore, we found that two classes of organizational capabilities are particularly significant in the process of ECM adoption: organizational resources and organizational monitoring.

Organizational resources – particularly specialized environmental resource – appear to matter greatly in the process of ECM adoption. These resources provide the embedded capacity, which enables firms to respond to external stimuli and implement environmental innovations. In effect, they create the opportunity space from which individual managers and work groups can experiment with and implement advanced environmental practices.

Organizational monitoring is also important. It provides a special type of organizational capability, which establishes quantitative of objectives, goals, standards and evaluation metrics that enable sample organizations to assess their progress toward stated goals. The findings suggest that organizational monitoring is perhaps the key differentiating factor in ECM adoption.

In addition, our findings suggest that there is at best a loose association between organizational innovativeness (measured as prior adoption of advanced business practices) and ECM adoption. We found a high rate of adoption of advanced business practices across both high- and non-adopters in the sample – in fact, non-adopters were more advanced in some categories than high-adopters. We believe this result reflects the widespread adoption of some version of advanced business practices by manufacturing establishments generally. We suggest however, that what distinguishes the ability of organizations to effectively utilize and theses practices are the adoption and use of organizational monitoring systems. Here, we contend that although advanced business practices may lead to improved business outcomes, they are alone insufficient to yield environmental performance gains.

Finally, our findings suggest that there is little relationship between geography and ECM adoption. The research finds that while there is some diffusion of ECM practices through supplier chains, such diffusion is not especially dramatic or significant. We identified two potential reasons for this lack of diffusion – the sizable geographic distance between the field research facilities and suppliers and customers, and a lack of desire on the part of sample facilities to engage in examinations of each others' internal processes.

Generally speaking, our findings suggest that organizational factors operate as a system. Organizational resources – particularly specialized environmental resources – create the capacity to respond to internal opportunities and external events. The use of quantitative goals and measurement systems provide the mechanism for focussing effort, identifying problem areas, and for measuring progress toward specified objectives. These systems enable organizations to optimize their processes in general, to improve their environmental process in particular, and to realize performance gains from adoption of innovative organizational practices broadly.

We encourage other studies to utilize this conceptual approach and to subject the concepts, claims and findings advanced here to rigorous empirical testing on larger samples of organizations.

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Appendix

Organizational Factor Scores for Sample Plants

S	HIGH-ADOPTERS								NON-ADOPTERS				
FACILITY	A	B	D	F	H	I	K	AVG	C	E	G	J	AVG
ORGANIZATIONAL RESOURCES													
Facility Size	5	5	1	5	5	5	5	4.43	1	1	3	1	1.5
Company Size	5	5	1	5	5	5	5	4.43	5	1	3	3	3
ORGANIZATIONAL RESOURCE SCORE	10	10	20	10	10	10	10	4.43	6	2	6	4	2.25
ENVIRONMENTAL RESOURCES													
Size of Environmental Staff	3	4	3	5	5	5	4	4.14	2	1	2	1	1.5
Experienced Environmental Staff	5	5	3	5	5	5	5	4.71	5	1	2	1	2.25
Tenure of Environmental Staff	5	5	5	5	5	5	5	5	2	4	5	1	3
ENVIRONMENTAL RESOURCE SCORE	13	14	11	15	15	15	14	4.62	9	6	9	3	2.25
BUSINESS PRACTICES													
ISO Certified	0	0	0	5	5	0	0	1.43	5	5	5	5	5
Mission Statements	5	5	0	5	5	5	5	4.29	5	4	3	0	3
Formal Quality Management System	5	5	0	5	4	2	4	3.57	5	0	0	0	1.2
JIT Inventory Control	4	5	0	4	2	5	3	3.29	5	4	5	1	3.75
Cross-Functional Work Teams	2	3	0	5	5	2	1	2.57	5	4	4	0	3.25
Problem-Solving Teams	2	5	0	3	5	5	1	3.43	5	0	5	0	2.5
BUSINESS PRACTICE SCORE	21	23	0	22	21	19	14	3.10	25	12	17	1	3.13
ENVIRONMENTAL MONITORING & SYSTEMS													
Explicit Environmental Objectives	5	5	0	5	5	5	5	4.29	5	0	1	1	1.75
Environmental Performance Monitoring	5	5	1	5	5	5	5	4.43	3	1	1	1	1.5
Provide Environmental Information to Workers	5	5	0	5	4	5	2	3.71	1	1	1	2	1.25
Environmental Cost Identification	1	3	1	4	3	4	5	3	1	2	1	4	2
Chemical Control Process	1	5	0	0	4	4	2	2.29	4	0	0	0	1
Regular Environmental Inspections	5	5	1	4	5	5	2	3.86	5	1	3	1	2.5
Environmental Audits of Suppliers	1	2	0	1	4	5	1	2	1	0	1	0	.05
MONITORING & SYSTEMS SCORE	23	30	3	24	30	33	22	3.37	20	5	8	9	1.5
OVERALL SCORE	67	77	16	71	76	77	60	3.88	60	25	40	17	2.28

Source: by authors