

Determinants of Environmental Innovation Adoption in the Printing Industry

The Importance of Task
Environment Versus
Firm Specific Factors

By
Sandra Rothenberg, Ph.D.

Professor, College of Business

Stelios C. Zyglidopoulos, Ph.D.

Professor, College of Business

Rochester Institute of Technology

A Research Monograph of the
Printing Industry Center at RIT

October 2003

No. PICRM-2003-04

Determinants of Environmental Innovation Adoption in the Printing Industry

The Importance of Task Environment Versus Firm Specific Factors

By

Sandra Rothenberg, Ph.D.
Professor, College of Business

Stelios C. Zyglidopoulos, Ph.D.
Professor, College of Business

Rochester Institute of Technology



A Research Monograph of the
Printing Industry Center at RIT
Rochester, NY
October 2003

With Thanks

The research agenda of the Printing Industry Center at RIT and the publication of research findings are supported by the following organizations:



Table of Contents

Abstract	2
Introduction	3
Literature Review: Adoption of Environmental Innovations.....	5
Nature of the Technology.....	5
Internal Factors.....	5
External Factors.....	5
Munificence.....	5
Dynamism.....	6
Environmental Technologies	7
Methods	9
Findings.....	13
Discussions and Conclusions.....	15
Endnotes.....	16
References.....	17

Abstract

In this paper, the impact that the task environment has on the adoption of environmental innovations by firms is examined. Specifically, the impact of two dimensions of a firm's external context—munificence and dynamism—is investigated. Both of these factors are studied by drawing on the relevant literature, developing a number of hypotheses, and testing these hypotheses with data drawn from the U.S. printing industry. The major findings are that firms in highly dynamic environments, as well as firms that have adopted productive innovations, are more likely to adopt a greater number of environmental innovations.

Introduction

Given increasing environmental demands by society, stakeholder groups, and regulatory agencies, business firms are continuously adopting innovations that reduce the impact their operations have on the natural environment. They do so at different rates, however. The difference in the rate of adoption of environmental innovations by firms and industries has received some attention in business and society literature. Various researchers have proposed and examined a number of factors that could play a role in explaining these differences, such as the nature of the technology, internal factors, and contextual (i.e., external) factors.

With regard to the adoption of environmental technologies¹, most research has focused on socio-political aspects of the environment, such as stakeholder demands, regulatory pressure, and external relationships (Ashford, Ayers, & Stone, 1985; Breyer, 1982; Dupuy, 1997; Gray & Shadbegian, 1997; Jaffe & Palmer, 1997; Jaffe & Stavins, 1995; Lanjouw & Mody, 1996; Sanchez & McKinley, 1998; Swan & Newell, 1995; Van Dijken, et al., 1999). Yet, in other areas of research on technology adoption, economic aspects of the environment have been found to be an important factor in the adoption rate of new technological innovations.

The question remains, how does the economic environment influence the extent to which firms adopt new environmental technologies?

This paper investigates the impact that external factors have in determining the adoption of environmental innovations by firms. In particular, the investigation concerns the impact of two dimensions of the firm's task environment—munificence and dynamism—on the adoption of environmental innovations. Munificence refers to the richness or leanness of the business firm's environment with respect to resources available to the firm (Aldrich, 1979; Castrogiovanni, 1991; Dess & Beard, 1984). Dynamism refers to the degree of instability and/or turbulence that characterizes a firm's environment (Aldrich; Dess & Beard).

A brief review of literature is included on the issues surrounding the adoption of environmental innovations and the notions of munificence and dynamism. This paper also presents a number of testable hypotheses and describes the methods used to collect and analyze the data. Finally, the major findings are reported, followed by a discussion of their research and managerial implications.

Literature Review: Adoption of Environmental Innovations

The factors that have been identified in the literature as influencing the diffusion of new technology can be divided into three categories: the nature of the technology, internal factors, and external factors. Research suggests that the factors that influence the diffusion of technology in general also play a role in the diffusion of environmental technologies.

NATURE OF THE TECHNOLOGY

Rogers (1983) identifies five basic attributes of innovation that influence the rate of diffusion: relative advantage, compatibility, complexity, “trialability,” and observability. Some of these concepts have been looked at in the context of environmental innovation. Bierma and Waterstraat (2001), for example, found that each of the factors outlined by Rogers played an important role in the diffusion of environmentally beneficial technologies in the chemical industry. Dupuy (1997), in a study of the Ontario organic chemical industry, found support for the notion that incremental innovations and innovations that are additions to current technology, such as abatement equipment, are most likely to diffuse earlier than technologies that are more difficult to incorporate into the production process.

INTERNAL FACTORS

The existing knowledge base and strategic orientation of a particular organization can have a critical impact on how the technological factors, discussed above, are perceived within an organization. Rogers (1983) stresses that the perception of the relative advantage of a technology has a greater effect on diffusion rates than the actual advantage. Van Dijken, et al. (1999) found that environmental innovation in the offset printing industry was related to both

overall business competence and the environmental orientation of a firm. Similarly, Au and Enderwick (2000), in a study of 298 companies, point to several internal factors that affect the rate of diffusion of technology, including perceived difficulty, past adoption experience, supplier commitment, and perceived benefits.

EXTERNAL FACTORS

Dill (1958) conceptualizes the notion of task environment as all aspects of the organization’s environment “potentially relevant to goal setting and goal attainment” (p. 410). Typically, according to Scott (1992), this conception of a firm’s or organization’s environment is narrowed down even further “in use to refer to sources of inputs, markets for outputs, competitors, and regulators” (p. 134). Such a conceptualization of the environment of organizations not only highlights the goal-achievement aspect of organizations and their dependence on their environment for resources (Scott)², but also allows the identification of a number of analytical dimensions that facilitate the study of the firms’ task environments. Two of the most prominent dimensions thus identified are munificence and dynamism.

Munificence

Drawing on prior works (Aldrich, 1979; Dess & Beard, 1984; and Pfeffer & Salancik, 1978), Castrogiovanni (1991) defines munificence as “the scarcity or abundance of critical resources needed by [one or more] firms operating within an environment” (p. 542). In other words, munificence refers to the capacity of an environment to sustain growth for one or more organizations (Aldrich). It is relevant for our purposes because many theorists and researchers have argued or found evidence that munificence influences firm behavior (Irwin, Hoffman & Lamont, 1998; Koberg, 1987).

For example, Aldrich suggests that lean environments (environments low in munificence) promote “cut-throat competitive practices” (1987) and reward organizations that are lean and efficient. Zyglidopoulos (1999) argues that because of the leanness and efficiency rewarded in environments with low munificence, firms tend to develop a short-term mentality concerning their return on investments and avoid prolonged technological experimentation along different technological paths. In other words, firms in lean environments tend to avoid investments not immediately contributing to their productive capacities, such as environmental innovations. Firms in lean environments are expected to try and save scarce resources, so that they can invest them in critical areas of operation. Therefore, to the extent that investing in environmental innovations would be considered an expense or a luxury not directly contributing to the competitiveness of the firm, it is reasonable to expect that firms that find themselves in lean environments avoid investing in non-essential innovations, such as some environmental technologies.

Other research suggests that environmental technology adoption may be particularly vulnerable to environmental munificence. Once regulatory requirements are met, additional environmental improvements are often seen as non-essential to the functioning of the organization. Many environmental technologies and process changes have a longer payback, if any (Lindsey, 1998). In fact, Carter and Dresner (2001) found that firms which encountered greater success with innovations in the environmental arena also tended to look at costs from a broader, longer-term life-cycle perspective. In times of slack resources, this may not be a significant issue, as firms are more likely to spend money on projects with longer payback times. When resources are tight, however, even in the most proactive firms environmental projects are likely to be first cut (Rothenberg, 1995). One anecdotal trend in the printing industry, for example, is to outsource environmental services during recessionary periods (Bravieri, 2001). Therefore, Hypothesis 1 follows.

Hypothesis 1: The greater the munificence of an organization's task environment, the greater the number of environmental innovations it will adopt.

Dynamism

Dynamism, as an analytic dimension of the task environment of an organization, was proposed by Dess and Beard (1984), who combined in a single dimension the dimensions of stability-instability and turbulence (Aldrich, 1979). The stability-instability aspect of dynamism refers to the unpredictability of environmental change, which distinguishes “between the rate of environmental change and the unpredictability of environmental change” (Dess & Beard, p. 56). Turbulence refers to the degree of interconnection between different environmental elements, which leads to externally induced changes, which are difficult to plan for (Aldrich). The notion of dynamism is relevant for these purposes, because a number of researchers and theoreticians have linked the idea of environmental dynamism (or parts of it) with the behavior of the organization. For example, Thompson (1967) regarded dealing with uncertainty as one of the paramount aspects of organizations. Koberg (1987) found that perceived environmental uncertainty was associated with the frequency of process and structural adjustments.

Stemming from such seminal work as Miles and Snow (1978), most research suggests that in dynamic environments firms tend to increase the rate of technology adoption. As stated by Buchko (1994, p. 414), in uncertain environments, firms “seek to identify and adopt new product and processes in an attempt to minimize the effects of an environmental that strategists understand poorly.” Koberg (1987) found that perceived environmental dynamism was a predictor of innovation, and was a greater predictor for radical innovation than incremental innovation. Tushman and Romanelli (1985) found that top managers in environments with substantial uncertainty tended to make more radical changes. Similarly, Brown and Eisenhart (1997), in their work on high velocity environments, found that in order to survive in these environments, firms need to

innovate rapidly. Given increased environmental uncertainty facing firms in dynamic environments, they may need to be more alert and aware of the technological possibilities of their situation if they are to survive.

Such awareness may also make firms aware of the environmental innovations available to them, along with the risks and benefits of these innovations. This may lead them to adopting environmental innovations earlier than firms in less dynamic environments. Aragon-Correa and Sharma (2003) suggest that firms are more likely to invest in resources to generate the capacity to improve environmental performance in uncertain environments. As an example, they point to a study by Prakash (2000), which documented how the Union Carbide accident firms responded to environmental uncertainty by investing in environmental programs (Aragon-Correa & Sharma). Another resource that firms can invest in when exposed to more uncertain environments is new environmental technologies. This leads to Hypothesis 2:

Hypothesis 2: The greater the dynamism of an organization's task environment, the larger the number of environmental innovations the organization will adopt.

ENVIRONMENTAL TECHNOLOGIES

The relationship of environmental dynamism to technology adoption, however, may not be as clear as it first appears when looking at environmental technologies. There is a difference between core productive technologies and environmental technologies. As discussed earlier, once regulatory requirements are met, additional environmental improvements are often

seen as non-essential to the functioning of the organization. In fact, Aragon-Correa and Sharma (2003) argue that only environmentally proactive firms respond to external uncertainty with increased investment in environmental resources. Most firms, however, may find investment in technologies that are not immediately productive, such as environmental innovations, to be too risky during times of high uncertainty. In other words, they would prefer to save their funds for a "rainy day" rather than invest them in technologies that will not immediately contribute to their ability to absorb the environmental uncertainty they face.

In addition, Aragon-Correa and Sharma (2003, p. 77) refer to "uncertain general business environments," and do not distinguish between economic uncertainty and social uncertainty. Research shows, however, that managers can distinguish different levels of uncertainty among different sectors of the environment, such as economic and political (Ebrahimi, 2000). The companies involved in the Union Carbide example were responding to an increase in social/political uncertainty, not economic uncertainty. It is reasonable to expect that firms would respond to these two types of uncertainty differently (Meznar & Nigh, 1995). Given the perceived non-core nature of environmental technology, while firms may increase adoption of these technologies during times of social/political uncertainty, they reduce it in times of economic uncertainty. This leads to Hypothesis 3:

Hypothesis 3: The greater the dynamism of an organization's task environment, the fewer the number of environmental innovations the organization will adopt.

Methods

The quantitative data come from a survey panel of 565 printers who volunteered to participate in a series of surveys administered by the Printing Industry Center at RIT.³ Participants were offered incentives such as early access to results, written material, and a free online seminar. Of the 565 printing firms on the panel, 128 participated in this particular survey.

Survey respondents replied to the survey via the Internet, through a survey designed with SPSS Data Entry Builder software. By having respondents enter data directly into an SPSS database, data-entry error was avoided. One of the primary limits of using an internet study, however, is the format in which questions can be written. In addition, surveys need to be short enough to prevent frustration on the part of the respondent. These and other potential problems were addressed through pre-testing.

Variable definitions and basic statistics are found in Table 1. For the dependent variable, data was gathered on dates and types of actual technology adoption. While there are many environmental challenges faced by the printing industry, this paper focuses on the technologies and processes that prevent the release of volatile organic compounds (VOCs). In the printing industry, many recent technological advances have created opportunities for improvements in environmental performance, particularly in the area of VOC reduction. For example, an array of low- or non-VOC inks, such as ultra-violet and electron-beam-curable inks and vegetable-oil- and water-based inks, have emerged as viable alternatives to solvent-based inks. Overall, 13 such technologies were examined; their sum created the dependent variable environmental technology. (See Table 1.)

Since the dependent variable was count data, a negative binomial model was used, which is

a variant of the basic Poisson model for count data. The negative binomial relaxes the Poisson assumption that the variance and mean of the dependent variable are equal (Greene, 1993). Therefore, the negative binomial is an appropriate version of the Poisson to use when the variance of the dependent variable is considerably greater than the mean, as it was in this case.⁴

For dimensions of munificence and dynamism, printing industry data drawn from the *Statistical Handbook for the Graphic Arts Industry* for the years 1993-1997 were used. More specifically, the value of yearly shipments per state was used to calculate both munificence and dynamism. The state level of analysis in measuring the munificence and dynamism of a firm's task environment was considered appropriate given that the printing industry is extremely fragmented (Kipphan, 2001). In calculating munificence, the growth of the total value shipments was used as measured by the regression slope coefficient, divided by the mean value of shipments for the period. To measure dynamism, the standard error of the regression slope coefficient was divided by the mean value of the shipments for the period. These measures were introduced by Dess and Beard (1984) and have been since used by numerous researchers to measure the munificence and dynamism of a firm's task environment.

A number of control variables were also measured. It is reasonable to expect that larger firms would tend to adopt a greater number of environmental innovations for the following reasons. First, it is quite likely that larger firms have more funds available to invest in such technologies. In other words, greater size might indicate the existence of slack resources that a firm might be willing to invest in environmental innovations. Larger firms are also more visible. This visibility might make them more

Methods

Variable	Measurement	N	Mean	SD	Min	Max
Dependent						
Environmental Technology	Number of environmental technologies adopted as of 2003 out of a list of 13 environmental friendly technologies	131	3.01	2.814	0	11
Independent						
Munificence	The growth of the total value shipments as measured by the regression slope coefficient, divided by the mean value of shipments for the period.	129	.0905	.0202	.0492	.163
Dynamism	The standard error of the regression slope coefficient, divided by the mean value of the shipments for the period.	129	.0184	.0109	.0002	.044
Control						
Size	Natural log of number of employees in plant	124	3.379	1.273	0	6.55
Return on Assets		86	.0477	.0739	.2	.25
Regulation	Number of times plant visited in past 3 years by EPA, OSHA, and State Environmental Regulatory Agency (sum)	130	1.523	2.276	1	10
Productive Technologies	Number of environmental technologies adopted out of a list of nine technologies	131	2.9618	2.099	0	8

Table 1. Variable Measurements and Descriptive Statistics

sensitive to public opinion, something that might motivate them to invest in environmental innovations as a way of avoiding potential damage to their reputation. Third, larger firms would most likely have a specialized department monitoring environmental issues. Therefore, we controlled for firm size, measured as the natural log of the plant's number of employees.

Research also suggests that the amount of organizational slack can also have a significant impact on firm investment in environmental technologies. First, relatively new technological innovations are often more expensive than older

technologies, so only profitable firms would be able to afford them. Second, as discussed earlier, many new environmental innovations do not pay off immediately, and less profitable firms would be more likely to focus on more short term investments. Such a rationale is in agreement with the findings of J. Näsi, S. Näsi, Phillips, and Zyglidopoulos (1997), who found evidence that the environmental social responsiveness of Canadian and Finnish forestry firms declined during periods when the companies experienced reduced profits. Firm profitability was controlled by measuring in terms of return on assets (ROA).

The extent to which the firm invested in other productive technologies was also controlled. This measure was important for a number of reasons. First, environmental technologies do not exist or function independently of the productive technologies in a firm. Quite often the two technologies complement each other, and a higher level of sophistication in productive technologies might allow or even demand a higher level of sophistication in environmental technologies. As Rogers (1983) argues, compatibility plays a significant role in the adoption of environmental innovations. Therefore it would be easier (and in some cases necessary) for firms that invest in innovations related to productive technologies to also invest in environmental innovations.

Second, firms that invest in a greater number of technological innovations related to production are most likely to be aware of the current technological possibilities in their field, which usually include possibilities in environmental innovations. In other words, additional environmental innovations for more technologically sophisticated firms would most likely mean an incremental adjustment of operations, and as noted earlier, incremental innovations tend to diffuse faster (Dupuy, 1997). Furthermore, besides being aware of available environmental innovations, technologically sophisticated firms might also have a better understanding of the benefits and tradeoffs related with the adoption of such technologies and so be less reluctant to invest in them. Therefore, the number of productive technologies the firm had actu-

ally adopted was measured. In addition to the 13 environmental technologies, the adoption dates of nine technologies were obtained. These technologies are generally known as those with which more modern and technologically advanced plants would operate.

Another critical external factor is environmental regulation. Without regulation, firms would have much less incentive to adopt technologies that, in essence, internalize the external costs of their manufacturing activities (Cetindmar, 2001). Some argue that there is a positive relationship between regulatory stringency and technical innovation in firms (Dupuy, 1997; Gray & Shadbegian, 1997; Lanjouw & Mody, 1996). Others argue, however, that regulations actually stifle innovation, or at the very least do not have any positive effect (Jaffe & Palmer, 1997; Breyer, 1982). Jaffe and Stavins (1995) and Ashford, Ayers, and Stone (1985) offer a more complex view of these relations and suggest that the type and form of regulation are important in determining the extent of their influence on innovation. Similarly, Sanchez and McKinley (1998) found that the impact of regulation on innovation depends in part on various internal features of the organization, such as R&D intensity, firm size, and flexibility. In order to capture the potential effect of regulation, the level of oversight (visits, audits) by the federal and local environmental agency was examined. This variable, however, had no significant effect, and therefore was excluded from further analysis.

Findings

Table 2 shows some of the basic correlations among the variables. The dependent variable, environmental technology, was significantly correlated to dynamism, the adoption of other productive technologies, and firm size. Firm size, in turn, was significantly related to ROA, with larger firms having a greater return on assets. Munificence, on the other hand, was not significantly related to any of the other variables, although the direction of its relationship to environmental technology was in the hypothesized direction.

Hypothesis 1 predicted that firms in lean environments would tend to adopt a smaller number of environmental innovations than firms operating within munificent environments. As suggested by Table 2, however, and shown in Table 3, this hypothesis was not supported by the evidence. The coefficient for munificence was negative (as predicted by Hypothesis 1), but it did not reach any levels of significance in the models.

	Munificence	Dynamism	Size	Environmental Technologies	Productive Technologies	Return on Assets	Regulation
Munificence	1						
Dynamism	.2721**	1					
Size	.0592	.0321	1				
Environmental Technologies	-.0588	.2030**	.2508***	1			
Productive Technologies	-.0764	.0310	.4751***	.5795***	1		
Return on Assets	-.1178	-.1449	-.1808*	-.0203	-.1149	1	
Regulation	.0841	-.1399	.1216	.0804	-.0306	-.0033	1

***Indicates statistical significance at the 0.01 level.

**Indicates statistical significance at the 0.05 level.

*Indicates statistical significance at the 0.10 level.

Table 2. Correlation Matrix

Findings

Hypothesis 2 predicted that firms in dynamic environments would tend to adopt more environmental technologies than firms in less dynamic environments. Hypothesis 3 predicted the opposite relationship. It was found that the coefficient for dynamism was significant and positive. In other words, as proposed by

Hypothesis 2, it was found that the greater the dynamism in the firm's environment, the greater the chance that the firm would adopt a higher number of environmental innovations. Hypothesis 2, therefore, was supported; Hypothesis 3 was not.

	1	2	3	4
Munificence	-4.67 (4.56)		3.21 (3.84)	
Dynamism	19.31 (8.39)**		12.28 (6.68)*	11.77 (7.11)*
Size		.15 (.080)*	-0.02 (.066)	
Return on Assets		1.2 (1.39)	1.84 (1.12)*	0.97 (1.12)
Productive Technologies			.244 (.038)**	.23 (.0368)***
Pseudo R2	.0096	.0103	.1038	.087

Note. The dependent variable is environmental technologies. Cells report variable coefficients and standard errors in parenthesis

***Indicates statistical significance at the 0.01 level.

**Indicates statistical significance at the 0.05 level.

*Indicates statistical significance at the 0.10 level.

Table 3. Negative Binomial Regression Models for Environmental Technologies

Discussion and Conclusions

The findings of this study contribute to the literature on the adoption of environmental innovations in a number of ways. First, with the factors in the firm's environment that influence the adoption of environmental innovations, the findings suggest that while munificence has no impact, dynamism plays a significant positive role. These findings are contrary to the assumption that firms would cut down their non-essential—environmental—expenditures in order to better deal with economic uncertainty. There are several explanations for this. First, perhaps many firms do not consider technologies to be “non-essential expenditures.” Second, it may be that in highly dynamic environments, the firms that survive are more capable, both in general and in terms of environmental management.

The findings also imply that a dominant factor in the adoption of environmental innovations is the degree to which the firm is also involved in the adoption of productive technological innovations. This relationship could hold for a number of reasons. First, firms that are actively involved with technology adoption could possess greater technical and scouting capabilities than firms that are not. These abilities would spill over into the area of environmental management. Second, investment in productive technology may reflect a less risk-adverse technology strategy. These firms would be better able to manage and less likely to be concerned with the risks associated with new technologies. Lastly, the relationship could also be due to the interrelationships among technologies. Often, environmental technology investments are delayed until other productive process changes are made. This minimizes the costs and risks of interference with production associated with the adoption of many environmental technologies.

Given these findings, it is important to note the limitations of this study. First, it is limited to one industry (printing). The high number of small firms and the nature of the technologies differentiate the printing industry. Therefore, some of the study's findings might not apply to other industries. Second, measuring munificence and dynamism at the state level may not be the most appropriate way to capture these dimensions; micro-level analysis may be required. Additional research is needed, however, to investigate munificence at micro and macro levels of analysis. Third, the study takes a limited view of the role of regulatory requirements. As discussed earlier, differences in regulatory pressures could have a significant impact on technology adoption rates. One of the problems is that in this sample, one of the major regulatory differences would be classification as a major or minor source under the EPA Clean Air Act. Because this classification is so highly correlated with firm size, this was not used as a measure in our regression. The control we did use was limited, and there may be more sophisticated ways to capture regulatory differences.

Despite these limitations, this study has several implications for research, policy, and management. This study shows strong support for the notion that the task environment does influence environmental technology adoption. In particular, in dynamic environments, firms will actually increase their rates of environmental technology adoption. For policy, it suggests that in order to encourage the adoption of environmental innovations, one can also focus on enhancing industries' overall ability to adopt new technologies in general. When looking at the development of environmental regulations, therefore, it might be less important to focus on environmental technologies than to increase regulatory flexibility so as not to impede tech-

Discussion and Conclusions

nology adoption. For managers, these findings suggest that firms can leverage their ability to adopt new technologies to improve their environmental performance. Moreover, the skills

associated with investments in environmental technologies may also be used to adopt productive technologies.

ENDNOTES

¹ In this paper, the term “external environment” or “task environment” refers to a firm’s operating context. The term “environmental technologies” refers to technologies that reduce a firm’s impact on the natural environment.

² Of course, this highlighting achieved through the notion of ‘task environment’ shifted attention away from other aspects of the firm’s environment, such as institutional aspects. But this is not an issue for this paper, since institutional aspects of a firm’s environments are not investigated here.

³ The panel was created by inviting a sample of 10,500 printers and packagers selected from the Dun & Bradstreet database. The sample was chosen to represent the variety of printing technologies and firm size. All firms with 20 or more employees are included in the sample (approx. 5,000). In addition, 50% of firms with between 10-19 employees and 15% of the firms with 9 employees or less were randomly selected.

⁴ For Environmental Technologies, for example, mean=3.02 and variance = 7.92

References

- Aragon-Correa, J. A. & Sharma, S. (2003). A contingent resource-based view of proactive environmental corporate environmental strategy. *Academy of Management Review*, 28(1), 71-88.
- Aldrich, H. E. (1979). *Organizations and environments*. Englewood Cliffs, NJ: Prentice-Hall, Inc.
- Ashford, N. A., Ayers C., & Stone, R.F. (1985). Using regulation to change the market for innovation. *Harvard Environmental Law Review*, 9, 419-466.
- Au, A. K.-M. & Enderwick, P. (2000). A cognitive model on attitude towards technology adoption. *Journal of Managerial Psychology*, 15(4), 266-282.
- Baptista, R. (2000). Do innovations diffuse faster within geographical clusters? *International Journal of Industrial Organization*, 18, 515-535.
- Bierma, T. & Waterstraat, F. (2001). Overcoming barriers to pollution prevention in small businesses. *Waste Management and Research Center Reports, RR-E075*. Champaign, IL: Illinois Department of Natural Resources.
- Bravieri, R. (2001). Outsourcing environmental services. *In-Plant Printer*, 41(6), 32.
- Breyer, S. (1982). *Regulation and its reform*. Cambridge, MA: Harvard University Press.
- Brown, L. A. (1981). *Innovation diffusion: A new perspective*. New York: Methuen & Co.
- Brown, S. L. & Eisenhart, K. M. (1997) *Competing on the edge: Strategy as structured chaos*. Boston: Harvard Business School Press.
- Buchko, A. A. (1994). Conceptualization and measurement of environmental uncertainty: An assessment of the Miles and Snow perceived environmental uncertainty scale. *Academy of Management Journal*, 37, 410-425.
- Carter, C.R. & Dresner, M. (2001). Environmental purchasing and supply management: cross-functional development of grounded theory. *Journal of Supply Chain Management*, 37(3).
- Castrogiovanni, G. J. (1991). Environmental munificence: A theoretical assessment. *Academy of Management Review*, 16(3), 542-566.
- Cetindamar, D. (2001). The role of regulations in the diffusion of environmental technologies: micro and macro issues. *European Journal of Innovation Management*, 4(4), 186.
- Czepiel, J. A. (1975). Patterns of interorganizational communications and the diffusion of major technological innovation in a competitive industrial community. *Academy of Management Journal*, 18(1), 6-24.

References

- Dess G. G. & Beard D. W. (1984). Dimensions of organizational task environment. *Administrative Science Quarterly*, 29, 52-73.
- Dill, W. R. (1958). Environment as an influence on managerial autonomy. *Administrative Science Quarterly*, 2, 409-443.
- Dupuy, D. (1997). Technological change and environmental policy: The diffusion of environmental technology." *Growth and Change*, 28, 49-66.
- Ebrahimi, B. P. (2000). Perceived strategic uncertainty and environmental scanning behavior of Hong Kong Chinese executives. *Journal of Business Research*, 49(1), 67-77.
- Gray, W. & Shadbegian, R.J. (1997). *Environmental regulation, investment timing and technology choice*. Cambridge, MA: National Bureau of Economic Research.
- Greene, W. (1993). *Econometric Analysis*, (2nd ed.). Englewood Cliffs, NJ: Prentice-Hall, Inc.
- Irwin, J. G., Hoffman, J. J., & Lamont, B. T. (1998). The effect of the acquisition of technological innovations on organizational performance: A resource-based view. *Journal of Engineering and Technology Management*, 15(1),25-55.
- Jaffe, A. & Palmer, K. (1997, November). Environmental regulation and innovation: A panel data study. *Review of Economics and Statistics*, 610-619.
- Jaffe, A. & Stavins, R. (1995). Dynamic incentives of environmental regulations: The effects of alternative policy instruments on technology diffusion. *Journal of Environmental Economics and Management*, 29, S-43-S-63.
- Keats, B. W. & Hitt, M. A. (1988). A causal model of linkages among environmental dimensions, macro organizational characteristics, and performance. *Academy of Management Journal*, 31(3), 570-598.
- Kelly, D. & Amburgey, T. L. (1991). Organizational inertia and momentum: A dynamic model of strategic change. *Academy of Management Journal*, 34, 591-612.
- Kipphan, H. (Ed.). (2001). *Handbook of print media*. Berlin: Springer.
- Koberg, C. S. (1987). Resource scarcity, environmental uncertainty, and adaptive organizational behavior. *Academy of Management Journal*, 30(4), 798-808.
- Koberg, C. S, Detienne, D. R. & Heppard K. A. (2003). An empirical test of environmental, organizational and process factors affecting incremental and radical innovation. *The Journal of High Technology Management Research*, 14(1), 21-45.
- Lanjouw, J. O. & Mody, A. (1996). Innovation and the international diffusion of environmentally responsive technology. *Research Policy*, 25, 549-571.
- Lindsey, T. C. (1998, Winter). Diffusion of P2 innovations. *Pollution Prevention Review*, 1-14.
- Meznar, M. B. & Nigh D. (1995). Buffer or bridge? Environmental and organizational determinants of public affairs activities in American firms. *Academy of Management Journal*, 38(4), 975-997.

- Miles, R. & Snow, C. (1978). *Organizational strategy, structure, and process*. New York: McGraw-Hill.
- Näsi, J., Näsi, S., Phillips, N., & Zyglidopoulos, S. (1997). The evolution of corporate social responsiveness: An exploratory study of Finnish and Canadian forestry companies. *Business and Society*, 36(3), 296-321.
- Noci, G. & Verganti, R. (1999). Managing green product innovation in small firms. *R&D Management*, 29(1), 3.
- Pfeffer, J. & Salancik, G. R. (1978). *The external control of organizations*. New York: Harper and Row.
- Prakash, A. (2000). Greening the firm: *The politics of corporate environmentalism*. Cambridge, MA: Cambridge University Press.
- Rogers, E. M. (1983). *Diffusion of innovations*. New York: The Free Press.
- Rothenberg, S. (1995). Extending the umbrella of social concern: Volvo's strategic approach to environmental management. *Corporate Environmental Strategy*, 3(2).
- Rothenberg, S. (in press). Knowledge content and worker participation in environmental management at NUMMI. *Journal of Management Studies*.
- Sanchez, C. M. & McKinley, W. (1998). Environmental regulatory influence and product innovation: the contingency effects of organizational characteristics. *Journal of Engineering and Technology Management*, 15, 257-278.
- Scott, W. Richard. (1992). *Organizations: rational, natural, and open systems*. Englewood Cliffs, NJ: Prentice Hall.
- Swan, J. A. & Newell, S. (1995). The role of professional associations in technology diffusion. *Organization Studies*, 16(5), 847-874.
- Thompson, J. D. (1967). *Organizations in action*. New York: McGraw-Hill.
- Tushman, M.L. & Romanelli, E. (1985) Organizational evolution: A metamorphosis model of convergence and reorientation. In: Cummings, L. L. and Staw, B. M., (Eds.), *Research in Organizational Behavior* (pp. 171-222.) Greenwich, CT: JAI Press.
- Van Dijken, K., et al. (1999). *Adoption of environmental innovations: The dynamics of innovation as interplay between business competence, environmental orientation and network involvement*. Boston: Dordrecht, Kluwer.
- Zyglidopoulos, S., (1999). Initial environmental conditions and technological change. *Journal of Management Studies*, 36(2), 241-262.



Rochester Institute of Technology
College of Imaging Arts and Sciences
55 Lomb Memorial Drive
Rochester, NY 14623
Phone: (585) 475-2733
Fax: (585) 475-7279
<http://print.rit.edu>