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Innovation in the Agro-Industry Sector in Costa Rica

Main Determinants

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Jeffrey Orozco and Carlos Murillo

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International Institute for Sustainable Development
161 Portage Avenue East, 6th Floor
Winnipeg, Manitoba
Canada
R3B 0Y4
Tel: (204) 958-7700
Fax: (204) 958-7710
E-mail: info@iisd.ca
Web site: http://www.iisd.org

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The multi-dimensional character of regional needs demands a balanced response that integrates social, environmental, economic and institutional aspects. This will be the only way to achieve sustainable development translated into ecologically- and socially-oriented patterns of production, consumption and regulation, and into an ethical and human commitment that takes into account the context of interdependence in which we live.

Contents

Introduction

The need to survive in the market has often been a powerful incentive for firms, pushing them to introduce innovations. In developing countries, firms must develop tacit, firm-specific knowledge to be able to grow, create skilled jobs, compete with imports and transnational corporations in the domestic market and export to increasingly demanding clients in the world market; all the while meeting significant environmental requirements.

Firm-specific knowledge is the result of costly and complex learning processes in which enterprises have to continuously acquire skills, resources and capabilities so they can receive, assimilate, use, adapt, change and innovate technologically. Since environmental problems are highly location- or firm-specific, there is also a need to develop innovative capabilities to find solutions to problems for which there are no "on-the-shelf" technologies available. Furthermore, the search for eco-efficiency and clean production methods—which can improve environmental performance with lower costs than traditional end-of-pipe systems—is closely linked to the availability of innovative capabilities at the firm level.

As discussed in the United Nations Industrial Development Organization (UNIDO) report *Competing through innovation and learning* (2002), these learning processes face risks, uncertainties and costs. Learning itself often has to be learned. At the same time, technological learning in a firm does not take place in isolation. The process is rife with externalities and is driven by links with suppliers of inputs and capital goods, competitors, customers, universities and research institutes. These linkages may lead to the development of local, regional and/or national systems of innovation and/or clusters in which new and cleaner technologies are created and diffused.

Firms' strategies to manage innovation may change according to the characteristics of markets and other conditions. In general, it is possible to identify both barriers to and motivators for innovation. Some issues factor into how firms manage innovation processes. Factors include returns and life cycles, risk management, R&D expenditures and the effectiveness of the system of innovation itself. As argued by Veugelers and Cassiman (1998), one important aspect within innovation management is the optimal integration of external knowledge, since innovation increasingly derives from a network of companies interacting in a variety of ways.

Considering that in Costa Rica, technology-sourcing strategies have not been well explored, the challenge of this research project includes examining innovation sourcing strategies and, more concretely, analyzing the main barriers to and motivators for innovation in the agro-industry sector in Costa Rica. Considering the lack of databases on the issue, a survey was developed for the sector.

Similar studies have identified classic relationships between innovation and company, technology or market characteristics. They have also examined factors determining make and/or buy decisions pertaining to technological innovation. For example, Veugelers and Cassiman (1999) tackle the question of firm innovative activities in terms of internal versus external technology creation and acquisition in two steps. For them, in the first step a firm decides whether or not to innovate. In the second step, the innovating firm decides how to source information. The choice is between making or buying technology. Veugelers and Cassiman's model—besides utilizing standard explanatory variables like size and measures of technological opportunity—includes variables that account for appropriation regimes for innovative profits as well as other obstacles and motives to innovate

To facilitate innovation processes and the acquisition of technological capabilities it is crucial to complement trade liberalization with innovation policies, including initiatives to foster the adoption and development of environmentally-friendly technologies, as is being incipiently carried out in some developing countries. While Small and Medium Enterprises (SMEs) are usually the priority targets of these policies, large domestic and foreign-owned firms are also increasingly targeted through the development of programs aimed at developing local suppliers, helping clients in their exports, fostering linkages with research and training institutions, diffusing environmental management systems, etc.

These new policies are not easy to design and implement, but a learning process in their application is taking place in several developing countries. The literature on systems of innovation gives some guidance, stressing the need to strengthen components of the systems and facilitating the ways in which they interact. The idea is that innovations are generated in interactive processes of learning. Normally, individuals cannot develop everything for themselves without the interaction of other agents, or without the use of existing knowledge (Edquist and Johnson 1997).

Under these conditions, the idea of systems of innovation seems to be convenient. With these approaches, the framework is broadened beyond the input-output system to include industries and firms as well as other actors and organizations, primarily in science and technology. Technology policy also comes into play. This analysis is carried out at national level. At the aggregate level, it studies R&D activities and the role played by universities, research institutes, government agencies, government policies and the linkages between them (see also Freeman 1988; Lundvall 1988 and 1992; Nelson 1988 and 1993; etc.).

Following these general ideas, this paper presents a report on barriers and motivator for innovation in the agro-industry sector in Costa Rica. The study has three objectives:

- to examine the relationship between innovation strategies at the firm level and some specific characteristics of innovation processes using data from a survey in two agro-industry export sectors;
- to analyze internal and external factors working as barriers or motivators for the introduction of cleaner technologies in firms; and
- to analyze components of the system of innovation[1] and its impacts on the innovation processes in the agro-industry sector.

This paper applies a survey to the agro-industry sector and compiles information of the components of the system of innovation.

1 Main institutions such as laws, property rights, work norms, financial facilities, etc.; characteristics of the industry such as performance, number and size of firms and employee complement, etc.; features of the educational, training and R&D systems; patterns of demand, structure of production and market pull; main policies and regulations by regulatory authorities and policy-makers; role of other stakeholders; features of the knowledge and learning processes in the sector; kind of interactions among different stakeholders in the sectors.

1. Factors facilitating or hindering innovation: The relevance of systems of innovation[2]

The discussion about determinants of innovation is very complex. To have a complete picture, it would be necessary to include several dimensions into the analysis. Actually, the use of simplistic models can seriously distort thinking (Kline and Rosenberg 1998).

There is an agreement that innovations are multi-causally explained. It is clear that a very wide range of factors influence the innovative performance of firms in any nation (Nelson 1992). It is also clear that different determinants probably support and reinforce each other (Edquist 2001).

In this paper, we follow a system-of-innovation approach. The argument is that the system as a whole plays a fundamental role in innovation, but it is also possible to study core determinants in the system. To describe this idea, we present a general model in next section.

1.1 A general model

There are many factors that could determine the innovation processes. "The list from the literature on innovation and systems of innovation includes such factors as: the institutional set-up, knowledge and learning, infrastructure, patterns of demand, production structures, government policies, feedback mechanisms, the science, universities and other organizations, the size and degree of affluence to the markets, the base of natural resources, the performance of the industry in which a firm is situated, the education and training systems, capabilities and stimuli generated within the firms, financial facilities, macroeconomic trends, technological bottlenecks, the R&D system, the possibilities of appropriation of the benefits in innovation processes and asymmetries among firms and other organizations" (Orozco 2004: 61).

It would be useful to weight the relevance of different factors. However, the literature doesn't give any model prioritizing the relevance of each determinant. This kind of weighting is only possible in empirical studies. From a theoretical point of view, it is possible to generate models organizing different determinates. This exercise can be useful for grouping determinates according to the main groups of actors in innovative systems. There is a general model in Figure 1. The model is based on a sectoral approach to systems of innovation. The model considers some of the relevant factors for each group and for various innovations, including institutions, knowledge/learning processes and the quality of interactions. There are also two more factors affecting innovation processes in general: path dependency and the level of uncertainty. Some other factors are grouped according to the different groups of actors who can have relations with firms and with each other.

2 This section is based in Orozco (2004: chapter 4).

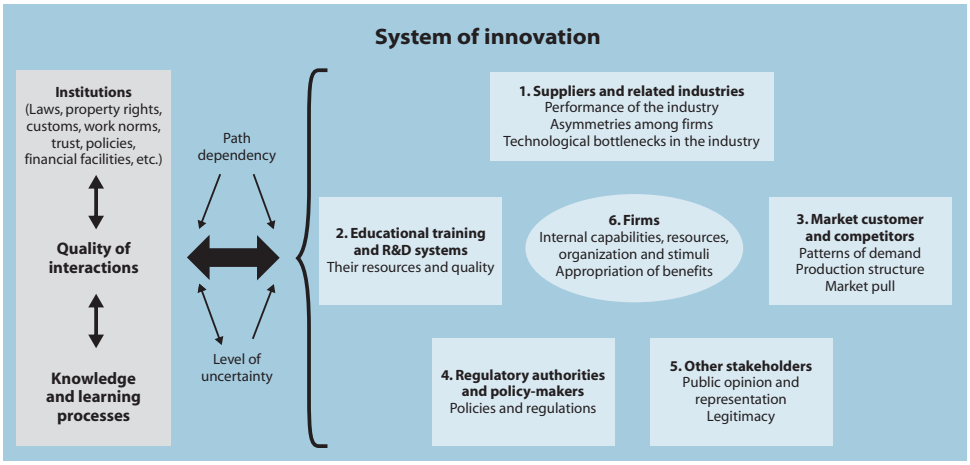
The main groups of actors in the sectoral systems of innovation in the model are:[3]

1) suppliers and related industries;
2) educational, training and R&D systems;
3) customers and competitors of relevant markets;
4) regulatory authorities, including all kind of policy-makers;
5) other stakeholders; and
6) the firm.

There are several factors facilitating or hindering innovation related to *suppliers and related industries*. This is the case for sector performance; the existence of asymmetries among firms; and the existence of technological bottlenecks in the sector. Into the group constituting *educational, training and R&D systems*, main factors include their resources; and the quality of these systems. In the group delimited by *market customers and competitors*, main factors facilitating or hindering innovation include patterns of demand; production structure; market pull; and financial facilities into the markets. Policies and regulation, including financial facilities,[4] for innovation are the main factors in the group of *regulatory authorities and policy-makers*. Finally, public opinion and representation as well as legitimacy are the main factors in the group of *other stakeholders*.

According to this model, the main determinants of innovation in *firms* include internal capabilities; resources; forms of organization; and stimuli to innovation. The possibility of appropriating the benefits of innovative processes is another relevant factor within firms.

Factors facilitating or hindering innovation



Source: Orozco 2004

Institutions are a key factor in innovation processes. Innovation is shaped by institutions and institutional change. Institutions also play a strong role in innovation processes because of their role in shaping human interactions. and because of their impact on learning processes.

3 This model is inspired by the Lindegaard's (1997) propeller model, but is more specific in focusing on firms instead of any kind of organization. It also considers a wider set of interactions and relevant determinants of innovation.

4 Financial facilities are institutions relevant for all groups of actors. Therefore, financial facilities are analyzed as a part of the group of institutions.

Innovation processes are determined both by stock, or existing knowledge and the capabilities to accumulate new knowledge, i.e., learning. More concretely, innovation is a result of learning and changes in the stock of knowledge.

Models of organizational learning are also relevant because they determine the capabilities of firms to handle knowledge and learning. Capabilities for interactive learning with other firms can differ in different models of organizational learning. One of the main differences among different models of organizational learning is the ability to handle and mobilize tacit knowledge.

The introduction of knowledge and learning processes at firm levels are shaped by other societal factors at the system level. Lam (1999) for example, argues that societal factors such as education and training systems and types of markets and careers are important factors in shaping organizational structures and processes within which the knowledge of a firm is embedded. However, the capabilities of systems to promote the introduction of knowledge can vary. Some systems can generate better conditions for learning processes than others. Several aspects characterizing the systems of innovation such as educational and training systems, the structure of markets and, in general, conditions for knowledge creation and diffusion into the system, affect patterns of learning and the base of knowledge at the firm level, determining innovation processes.

The quality of interactions is a key determinant of innovation processes because innovation is a social process that includes the participation of different stakeholders. There are several kinds of actors participating in innovation. For OCDE (1997), these actors are primarily private enterprises, universities and public research institutes and the people within them. Innovation processes are affected not only by the number of interactions within systems, but also by the specific contribution that interactions make in terms of solving specific key issues as processes unfold (Orozco 2004).

The quality of educational, training and R&D systems—measured in terms of resources, competencies and organization—factor significantly in determining innovation at the country or sector level. These systems provide firms with a flow of people with the required knowledge and skills to innovate (Lundvall 1992; Nelson 1992). In a similar way, universities and similar institutions are factors determining innovation because scientists and engineers from universities often go into their industry field to get formal training. Besides, in most (but not all) countries scientists and engineers are the locus of a considerable amount of research in the disciplines that are associated with particular technologies (Nelson 1992).

> *The production structure affects the innovation performance because technological possibilities and bottlenecks are different from sector to sector. The structure of demands matters because it affects public and private consumer learning, which is necessary to keep aggregate demand increasing in line with production capacity*. – Gregersen and Johnson 1998: 107

A relevant factor inside firms is internal organization. The interaction between different departments is crucial. It becomes important because most innovations are developed by firms (Orozco 2004).

One aspect that firms evaluate when deciding whether to invest in innovation is the earning potential. Innovation is, in this way, influenced by the appropriation of the benefits of innovation. Johnson (1992) argues that the distribution of benefits; cost and opportunities; and risks between people interacting influence the processes of innovation. It influences the information communicated, the interaction undertaken and the efforts put towards these activities.

Path dependency is a key factor for innovation. Actually, past options and strategies as well as past performance are determinants of innovative performance in the present and future. One firm cannot begin an innovation process without considering knowledge and resources as well as innovation experiences in the past. In that sense, the "past" is a key determinant of innovation. In the literature, this has been discussed in terms of path dependency and technological paradigms and trajectories. At the firm level, the notion of path dependency is centred on the idea of positive returns and is located in different domains: technology as hardware; knowledge base; and routines (Coombs and Hull 1998: 242).

The level of uncertainty is a determinant of innovation. Dosi distinguishes between uncertainty and strong uncertainty. The first is defined in terms of imperfect information about the occurrence of a known list of events. With strong uncertainty not only is the list of possible events unknown, but also the consequences of particular actions for any given event. The presence of strong uncertainty in most innovative searches leads firms to work with relatively general and event-independent routines. This also points to the importance of particular organizational arrangements for the success or failure of individual innovative attempts (1998: 1135).

1.2 Factors facilitating or hindering the introduction of cleaner technologies

For Gunningham and Sinclair (1997), the majority of barriers for firms to move towards cleaner production can be placed into one of two categories: those that are internal to the firm; and those that are external to the firm. Their report identifies the main barriers—or factors hindering the introduction of cleaner technologies—as follows:[5]

Internal barriers

- a lack of information and expertise;
- a low awareness of environmental issues;
- competing business priorities, (i.e., especially the pressure for short-term profits);
- bounded rationality in decision-making processes;
- financial obstacles;
- lack of communication in firms;
- middle management inertia;
- force obstacles; and
- difficulty in implementing cleaner technology.

External barriers

- the failure of existing regulatory approaches;
- difficulty in accessing cleaner technology;
- difficulty in accessing external finance;
- perverse economic incentives;
- an absence of markets for recycled goods; and
- economic cycles.

5 Both internal and external motivators and barriers in this discussion are considered in my model. These aspects were organized taking into consideration the main actors playing a role in determining respective factors. (consider revising this footnote: 1)this footnote falls under internal barriers—not internal external barriers or motivators, so the footnote is confusing; 2) define "this discussion," 3) my model, and 4)"respective factors."

The main motivators and drivers identified by Gunningham and Sinclair (1997) include: government regulation; the ability to share information through networking and business partnerships and access to external expertise, particularly for smaller firms; the desire to maintain good community relations, particularly for larger firms; the convergence of more efficient production processes with sophisticated cleaner production processes, such as environmental management systems; and access to financial incentives for investment in new, cleaner technology.

2. Determinants of innovation in the Costa Rican agro-industry sector

This section describes some relevant results of the survey. Data is used to describe the main characteristics of innovation processes and firm strategies. It also provides a brief description of the main factors determining innovation in the agro-industry sector. Some basic elements of the system of innovation are studied by analyzing the interactions of firms with relevant system actors. Finally, there is an analysis of activities for environmental protection and barriers for cleaner production. Descriptive statistics are used for this analysis.

2.1. Data

Data comes from a survey of managers as of the first part of 2005. The population of survey subjects consists of all firms in the agro-industry sector in the metropolitan area of Costa Rica. However, because of the small number of firms in the sector, the survey was expanded to include the whole population of Costa Rica. A hundred and eighty-seven firms were sent surveys. Forty-two responses were received, yielding an adjusted response rate of 22 per cent.

In the survey, managers were asked to answer questions normally included in innovation surveys from the Bogotá Manual. They were contacted by telephone to make appointments. The members of the survey team then visited the firms to complete the survey. In some cases, the respondents asked for some time to look for information and it was necessary to undertake a second or even third visit. Some of the firms rejected responding to the survey (16 firms), arguing that they answered a similar questionnaire some months ago. A majority of potential respondents (129 firms) began answering the survey and then didn't complete it, arguing that they did not have the necessary information.[6]

2.2. Innovation strategy at firm level and some specific characteristics of innovation processes

Most of the respondents have developed innovations in the last three years: 31 of the 42 firms made some innovations in products; 30 introduced innovations in processes; 24 developed organizational innovations and also 24 innovated in marketing; and only eight firms did not introduce any kind of innovation. In contrast, several firms worked on different innovations simultaneously.

The innovations developed by firms impacted their performance in different ways. As shown in Table 1, innovations in most of the firms had high economic impacts because of improvement in the quality of products. As well, firms were able to develop a wider array of products. The firms also benefited economically in terms of market share.

6 This situation seems to show a poor management of innovation issues or even a lack of innovation in the firms.

However, only seven firms benefited from high economic impacts. These firms reduced the use of raw materials and other inputs, which saved money. Only eight had significant reductions in energy consumption. In general, innovations made it possible for 22 firms to increase market participation or open new markets for their products. In summary, innovations had both high and medium economic impacts in the performance of the firms. This seems to be a key incentive for investing in innovation processes.

Table 1. Impacts of innovation: performance issues according to impact levels

Performance issues	Level of impact			
	High	Medium	Low	Irrelevant
Improving the quality of products	28	4	0	1
Establishing a wider array of products	24	3	3	–
Holding marketing share	28	1	1	2
Increasing market share	22	4	3	3
Opening new markets	22	6	3	1
Increasing the capacity of production	16	10	1	5
Increasing the flexibility of production	14	8	3	6
Reducing costs	9	10	6	7
Reducing the consumption of raw materials and inputs	7	9	4	13
Better use of worker competences	20	6	1	6
Reduction in energy consumption	8	11	3	11
Improvement in environmental and security issues	19	5	3	5
Reaching national standards	13	4	7	5
Reaching international standards	11	4	6	9

Note: only 34 firms answered this specific series of questions. Therefore, there were eight missing answers.

Firms use different sources to acquire the necessary information to develop innovations, as shown in Table 2. The main sources are internal to the firm. A big group of firms also use knowledge gained from customers and competitors. Universities and R&D centres are also relevant, but only for a few firms. Information also comes from advisors, conferences, the Internet and magazines and catalogues, (but less firms use these sources).

Table 2. Number of firms using different sources of information for innovation activities according to the relevance of each source

Sources of information	Relevance	
	High	Medium
Internal sources to the firm	21	12
A related firm	9	14
Head office	5	0
Customers	21	5
Competitors	18	4
Suppliers	11	16
Universities (centre of technological I&D)	9	8
Advisors, experts	9	10
Fairs, conferences	8	12
Magazines, catalogues	9	9
Databases	6	8
Internet	8	14

The firms have also invested in several activities in order to facilitate innovation processes. As is shown in Table 3, firms invested in activities including: training; contracts of technology; capital goods; hardware and software; R&D; engineering and industrial design; and management. These activities have been oriented both for innovations in products, processes, organizational innovations and improvements in marketing. An important group of firms benefited from those investments, especially in terms of internal R&D and training. But in general, most of the firms doing this kind of investment got positive results.

Table 3. Firms with investment in different activities designed to facilitate innovation; organized according to kind of innovation

Activities	Product	Process	Organization	Marketing	Positive result
Training	22	22	22	18	27
Contract of technology	17	19	16	16	25
Capital goods	22	21	16	14	23
Software	18	19	23	21	26
Internal R&D	30	27	22	24	28
External R&D	15	10	11	15	18
Engineering and industrial design	16	15	15	11	19
Hardware	15	19	24	21	23
Management	14	18	16	16	22

An interesting result is that only a few firms are developing their own patents. Actually, there are only eight firms that own patents in Costa Rica or abroad and only six are exploiting their patents in Costa Rica.

2.3. Factors facilitating or hindering innovation

Table 4 shows the relevance of a large number of factors that hinder the innovation process in the agro-industry sector in Costa Rica. However, only a few firms indicate that these factors have high relevance in terms of inhibiting this process. Taking into consideration both high and medium relevance, more firms mention: the lack of trained workers; the structure of the market; difficulties in accesses funding for innovation; and poor organization related to science and technology. Other factors like physical infrastructure and small market size are also relevant barriers to innovation for several firms.

The property right system is only a barrier for three firms. It is also interesting that only two firms consider risks associated with innovation as a factor hindering innovation processes. Something similar is truth for organizational rigidity and for the fact that innovation often takes time to produce returns.

Table 4. Number of firms with high or medium relevance of barriers for innovation, according to different factors

Factors	Relevance	
	High	Medium
Lack of trained workers	7	13
Organizational rigidity	2	7
Risks associated with innovation processes	2	12
Long return period	2	9
Small size of the market	6	11
Structure of the market	6	12
Show dynamism of technological change in the sector	3	9
Difficulty in accessing financial resources	8	13
Lack of opportunities to collaborate with other firms or organizations	8	7
The ease of others to imitate	6	11
Insufficient information about markets	4	14
Insufficient information about technologies	5	12
Problems associated with promoting S&T at the public policy level	7	2
Weak development of institutions related to S&T	6	13
Problems with physical infrastructure	8	9
Property rights system issues	3	5
High cost of training processes	8	9

2.4. Networking and innovation

In general, firms have interactions with different actors, especially to innovate. In Table 5 it is clear that most of these actors are relevant to the agro-industry sector. Firms have interactions with universities, technology centres, laboratories and R&D firms, customers, suppliers and advisors. Few firms, however, have interactions with other firms or with agencies and governmental programs in regards to science and technology.

Table 5. Number of firms having interactions with different actors to promote innovation

Actors	Interactions	
	Yes	No
Universities	25	16
Technology centres	20	21
Institutes for technical training	12	29
Laboratories/R&D firms	23	18
Other organizations related to R&D	9	32
Suppliers	32	9
Customers	29	12
Head office	7	34
Firms in the same sector	11	30
Other firms	4	37
Advisors	17	21
Agencies or governmental programs for S&T	5	36

2.5. Innovation and environmental protection: Barriers and drivers

Awareness about environmental issues has been increasing in Costa Rica. This also seems to be the case in the agro-industry sector, where only one of the interviewed firms has not invested in any kind of activities to enhance environmental protection.

Table 6. Number of firms with investment to enhance environmental protection

Kind of investment	Yes	No
General investment for environmental protection	41	1
Investment in system and equipment for water treatment and disposal	20	22
Actions for remediation of environmental impacts	18	24
Improvements in the efficiency of water use, raw materials and energy	15	27
Changes to reduce polluting processes	14	28
Substituting polluting materials	6	36
Development of environmental-friendly products	5	37
Internal or external recycling	4	38
Environmental certification	0	42

Many firms are investing in water treatment and disposal and on actions to remediate environmental impacts. Fewer firms have adopted pollution prevention approaches: 15 for improvements in the efficiency of water use, raw material and energy; 14 for changes to reduce polluting processes; but only six for substituting polluting materials; five for developing environmental-friendly products; and four for internal or external recycling. None of the firms have invested in environmental certification (Table 6).

Table 7. Number of firms with barriers to technologies to enhance environmental protection

Barriers	Yes	No
Inexistence of technologies in the international market	40	2
Inexistence of technologies in the local market	20	22
Lack of adaptation of available technologies to the firm's needs	13	29
The available technologies are protected by property rights, patents or other mechanisms	4	38
Lack of information on available technologies	2	40

The main barrier to access to technologies to enhance environmental protection is the inexistence of such technologies in the international or national markets. Only four firms mentioned property rights or patents in the available technologies; and only two mentioned lack of information as a factor hindering access to these technologies.

References

Alorcta, L. and W. Peres (1997). "Innovation systems and technological specialization in Latin America and the Caribbean," *Research Policy*, 26(1998): 857–881.

Arocena, R. and J. Sutz (1999). *Looking at national systems of innovation from the South*. Paper presented in the Conference on National Innovation System, Industrial Dynamics and Innovation Policy, Danish Research Unit for Industrial Dynamics (DRUID), June 9–12, Rebild, Denmark.

Bozeman, B. (2000). "Technology transfer and public policy: A review of research and theory," *Research Policy*, 29: 627–655.

Breschi, S. and F. Malerba (1997). "Sectoral innovation systems: Technological regimes, Schumpeterian dynamics and special boundaries," Edquist, C. (ed.), *Systems of innovation technologies, institutions and organizations*. London: Francis Pinter.

Centre for Corporate Environmental Management (CCEM) (1998). *Environmental management tools for SMEs: A handbook*. Environmental Issues Series. No. 10. Edited for the European Environmental Agency by Richard Starkey.

Christensen, P., Holm, E. and A. Remmen (1997). *Environmental management programs: Promoting new forms of reflexive governance in Danish industry*. Paper to 6th Greening of Industry Conference, The Cleaner Technology Group, Aalborg University, November, Denmark.

Cimoli, M. (ed.) (2000). *Developing innovation systems: Mexico in the global context*, forthcoming in the Pinter Series: Science, Technology and International Political Economy, London and New York.

Davenport, T. and L. Prusak (1998). *How organizations manage what they know?* Working knowledge. Boston: Harvard Business School Press.

Den Hond, F. (1996). *In Search of a useful theory of environmental strategy: A case study on the recycling of end-of-life vehicles from the capabilities perspective*. Ph. D. Thesis, Vrije Universiteit Amsterdam.

Edquist, C. (ed.) (1997). *Systems of innovation: Technologies, institutions and organizations*. London and Washington: Pinter.

——- (2001). *The systems of innovation approach and innovation policy: An account of the state of the art*. Lead paper presented at the DRUID Conference, Aalborg, J. 12–15, 2001, under theme F: "National Systems of Innovation, Institutions and Public Policies." Draft.

Edquist, C. and B. Johnson (1997). "Institutions and organizations in systems of innovation," Edquist, C. (ed.) *Systems of innovation: technologies, institutions and organizations*. London and Washington: Pinter/Cassell Academic.

Ergas, H. (1987). "Does Technology Policy Matter?" in Guile, B. and H. Brooks (eds.) *Global industry: Companies and nations in the world economy*. Washington DC: The National Academies Press.

Estrin, S. and A. Rosevear (1999). "Enterprise performance and ownership: The case of Ukraine," *European Economic Review*, 43(4–6): 1125–1136.

European Environment Agency (1998). *Environmental management tools for SMEs*. Environmental Issues Series; No. 10.

Freeman C. (1991). *The nature of innovation and the evolution of productive system*. OECD–TEP, Technology and productivity, the challenge for economic policy, TEP Program

——- (1992). *The economics of hope: Essays on technical change, economic growth and the environment*. London: Pinter.

——- (1996). *The economic of industrial innovation*. Third Edition. London: Pinter.

Gunningham, N. and D. Sinclair (1997). *Barriers and motivators to the adoption of cleaner production practices*. Australian Centre for Environmental Law, The Australian National University.

Johnson, B. and L. Bengt-Ake (1992). "National systems of innovation and institutional learning," paper presented at the 4S/EASST joint conference in Göteborg, August, 1992.

Jørgensen, T. and A. Remmen (1995). "Implementation of environmental management systems," In proceedings at the Fourth International Research Conference of the Greening of Industry Network. Toronto, Canada. November 1995.

Katz, J. (2000). *Pasado y presente del comportamiento tecnológico de América Latina. Serie Desarrollo Productivo*, CEPAL–ECLAC.

——- (2001). "Structural change and labor productivity growth in Latin American manufacturing industries 1970–96," *World Development*, 28(9): 1583–1596.

Local Sustainability Project and Deni Greene Consulting Services (1996). *Getting ahead of the game: A cleaner production handbook for local government. An anticipatory approach to environmental management*. Prepared for The Environment Protection Agency. Centre for Resource and Environmental Studies. Australian National University.

Lundvall, B.-Å. (1988). "Innovation as an interactive process: From user-producer interaction to national system of innovation," pp. 349–369 in Dosi *et al*. (eds.), *Technical change and economic theory*. London: Pinter Publishers.

——- (ed.) (1992). *National systems of innovation: Towards a theory of innovation and interactive learning*. London: Pinter.

Lundvall, B.-Å., Johnson, B., Andersen, E. and B. Dalum (2001). *National systems of production, innovation and competence-building*. Paper presented at the Nelson and Winter DRUID Summer Conference, Aalborg Congress Center, Aalborg, Denmark, June 12–15 2001.

Meeus, M. and L. Oerlemans (2000). *Firm behavior and innovative performance: An empirical exploration of the selection. Adaptation Debate*. En: Research Policy 29 (2000), 41–58, April. Eindhoven on Center for Innovation Studies, Faculty of Technology Management, Eindhoven University of Technology, Netherlands.

Nelson R. (1992). "The role of knowledge in R&D efficiency," *Quarterly Journal of Economics*, Cambridge, 97(3): 453–471, August.

Nelson R. and N. Rosenberg (1993). "Technical innovation and national systems," Nelson R. (ed.), *National innovation systems: A comparative analysis*. New York, Oxford: Oxford University Press.

Nelson, R. and B. Sampat (2001). "Making sense of institutions as a factor shaping economic performance," *Journal of Economic Behavior & Organization*, 44(2001): 31–54.

Nelson, R. and S. G. Winter (1982). *An evolutionary theory of economic change*. Cambridge. Massachusetts: Harvard University Press.

Nelson, R. R. (ed.) (1993). *National innovation systems: A comparative analysis*. New York: Oxford University Press.

Orozco, J. (2004). "Innovation and performance improvements in the cooperative sector, Costa Rica," SUDESCA Research Papers No. 38.

Remmen, A. (1995). "Pollution prevention, cleaner technologies and industry," in Arie Rip, Thomas J. Misa and Johan Schot (eds.). *Managing technology in society: The approach of constructive technology assessment*. London, U.K.: Pinter.

——- (1997). *Innovation concepts and cleaner technology: Experience for three Danish actions plans*. Paper for 4th European Roundtable on Cleaner Production, November. Oslo.

——- (1999). "Greening of industry," Technological and Institutional Innovations. SUDESCA, Conference, Costa Rica.

——- (2001). "Greening the Danish industry: Changes in concepts and policies," *Technology Analysis and Strategic Management*, 13(1): 53–69.

Remmen, A. and C. Smink (1999) *Reforming environmental regulation, New ways to accomplish industrial appropriation of pollution prevention*. Aalborg University, Department of Development and Planning. Denmark.

Rennings K. (2000). "Redefining innovation: Eco-innovation research and the contribution from ecological economics," *Ecological Economics*, 32(2): 319–332.

Veugelers, R. and B. Cassiman (1999). "Make and buy in innovation strategies: Evidence from Belgian manufacturing firms," *Research Policy*, 28(1): 63–80.

Welford, R., (ed.) (1998). *Corporate environmental management one: System and strategies*. Second edition. London: Earthscan Publications Ltd.

Welford, R. and R. Starkey (1996). *Business and the environment*. London: Earthscan Publications Ltd.