

The Jerusalem Institute for Israel Studies
The Center for Environmental Policy
Established by the Charles H. Revson Foundation

Eco-Innovation in Industrial Firms

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2009

The Center for Environmental Policy Studies Series no. 34

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This publication was made possible through funding by the Charles H. Revson
Foundation.

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ACKNOWLEDGMENTS

Hundreds of officials, most of them managers of industrial firms, participated in the preparation of this research. All took time off from the pressures and demands of their jobs to invest valuable time in interviews with me and my fellow researchers. My special thanks to the firm managers who participated in the case studies – for their cooperation, for their willingness to provide information and for their readiness to supplement this information with responses to countless questions, subsequent to our meetings. It is impossible to enumerate all of the other interviewees who contributed to this research with their advice and guidance, which included staff members of the Ministry of Environmental Protection, local environmental authorities, the Manufacturer's Association of Israel and academia.

Special thanks go to the Jerusalem Institute for Israel Studies and to its director general Ora Ahimeir for providing the framework and giving their support for this research and its publication. Thanks are also due to Eran Avni and Asaf Malchi who assisted with the interviews in the firms, to Efrat Sa'ar for assisting in the processing of the statistical data, to Galit Hazan who was responsible for the administration of the research and to Varda Ben-Yosef for her editing.

This study would not have been possible without the dedicated help and guidance of Prof. Eran Feitelson and Prof. Morris Teubal of the Hebrew University of Jerusalem who set aside many hours of work and supported the long and arduous stages of the study. Special thanks to the Hebrew University and to Prof. Feitelson for their help in funding this research.

Special mention should also be made of the assistance of Eng. Dror Ben Aharon and of chemist Yael Kelner who spent much time in analyzing the complex technology of each of the eco-innovation projects. Thanks to Dov Basel, Neri Nadar and Ra'anan Boral, who read previous versions of the manuscript and made many important and helpful comments and to Dr. Amir Edelman for his guidance and for his enlightening comments in the different stages of the research.

Thanks to the participants of the roundtable panel and the accompanying committee for their valuable comments: Prof. Yoram Avnimelech, Dr. Yeshayahu

Bar-Or, Dr. Miki Haran, Prof. Moshe Yustman, Prof. Uri Marinov and Prof. Eran Razin. Special thanks to Prof. Yossi Zeira for his help in writing the market failure economic model and to Prof. Omer Moav for his help in focusing the methodological thinking during our joint cycling sessions.

And last but not least – to my dear family, who over a period of seven years had to become accustomed to another family member called "doctorate" that dad cared for, allotted a great deal of time to and heaped love on instead of spending time with them, and especially to Eilat, my wife, who provided invaluable help as well in preliminary editing and proofreading.

Dr. Nir Ben-Aharon is an economist specializing in technological economy, industrial innovation and environmental quality. In addition to his involvement in different research projects on managing innovation and environmental quality in industry and business, Nir managed, within the framework of the Jerusalem Institute for Israel Studies, the "Nitzotz" (Spark) program – a government program that assisted hundreds of firms to become more creative and to implement innovation projects. This research study is based on the author's doctoral dissertation on the subject of eco-innovation in industry.

ABSTRACT

Over the past two decades a major change took place in Israel's industry – it significantly reduced its industrial pollution and decreased the gap between Israel and most Western countries in this field. This reduction required the firms to expend major funds on environmental technologies, most of which exacted a heavy economic cost while making no contribution to the production process. However, solutions exist which improve the environmental efficiency of firms and enable them to consume less resources and reduce their environmental pollution, while cutting down on expenses. Innovative solutions such as these are defined as "eco-innovation" and are the subject of this research.

As part of the research study, a model which describes the primary factors which influence industrial firms to undertake eco-innovation was constructed. In this model the demand for eco-innovation solutions is based on the willingness or necessity of the firms to reduce their pollution. The supply of innovative environmental solutions is enabled by the development of technologies: some of them implemented by the firms, within the factory, and some made possible through the assistance of external companies which offer environmental solutions to the firms. This demand and supply allows for the creation of a market for eco-innovation solutions. Generally, a "market" is a mechanism which facilitates efficiency in resource allocation, but in the case of eco-innovation, the market encompasses only 50% of the innovation projects. The market for innovative solutions is immature due to the existence of transaction costs and other barriers, which make it difficult for industry to become more efficient and to implement "win-win" solutions.

In order to study eco-innovation in industry, 249 firms were investigated – those with the highest probability for implementing environmental actions. Their representatives were interviewed and questioned about the eco-innovation projects that they conducted in the 16 year period spanning between 1989 and 2004. The study showed that the investigated firms carried out 369 environmental projects, 245 of which were defined as "technological eco-innovation projects" and 124 of which were defined as "conventional environmental projects" and served as a control group. The number of eco-innovation projects was found to increase over the years.

The most common projects which were conducted by the firms were at the innovation level of "new to the country" (47% of the projects), which is characteristic of industry whose main objective is to minimize the gap between Israel and the world. In 16% of the projects the eco-innovation level was characterized as "new to the world," and in 37% of the projects, the eco-innovation level was defined as "new to the firm."

It was found that actions taken by the Ministry of Environmental Protection – such as making business licensing conditional on the fulfillment of environmental requirements, issuing hazardous substances permits and providing grants for hazardous waste minimization projects – assisted the development of eco-innovation. On the other hand, enforcement activities tended to lower eco-innovation: firms which were subject to environmental enforcement by the Ministry of Environmental Protection – through the dispatch of warnings, holding of hearings or issuance of orders – tended to conduct fewer eco-innovation projects than similar firms that were not subject to enforcement procedures. Firms under enforcement could not allow themselves to be exposed to any further risks after being legally targeted by the ministry, even if eco-innovation could have benefited them economically and strategically. Therefore, they chose to solve their environmental problems in conventional rather than innovative ways.

In most cases, the firms implemented eco-innovation projects both for environmental and economic reasons, underlining the fact that a "win-win" situation is possible in this area. However, there was a wide variation in the costs of the eco-innovation projects, which ranged from thousands of dollars to tens of millions of dollars per project.

Other factors which were found to contribute to eco-innovation were connections with companies abroad (both clients and company owners), negative environmental articles published in newspapers about the firms and the existence of environmental management systems (ISO 14001).

The research discovered a market failure in the field of eco-innovation. This failure derives from the uncertainty which is associated with the results of technological innovation compared to emission performance standards, which require uncompromising compliance with criteria. In the case of emission performance standards firms are penalized for non-compliance with emission standards but are not compensated for reducing pollution to below standard

values by means of innovative solutions. Therefore firms do not implement projects which would be beneficial to both the public and the state. Since this failure arises from a policy that aims to reduce pollution, it should be termed a Government failure.

The Government failure of eco-innovation was examined in several ways by using data from the eco-innovation projects. One test compared eco-innovation projects to conventional projects conducted by firms. It was found that projects conducted in order to comply with emission performance standards tended (significant tendency) to implement conventional solutions which are not innovative – in comparison to projects which were not designed to comply with emission standards. It was also found that if a firm decides to conduct an innovation project for the purpose of complying with an emission standard, it tends to seek the assistance of an external company in implementing the project, thereby reducing the risk of non-compliance with the standard. Turning to an external company for help in an innovation project appeared to serve as a mediating factor between the need to comply with an emission performance standard and the need to conduct an eco-innovation project. It was further found that the technological complexity of an eco-innovation project also drives firms to seek external help in development, and as technological complexity increases, firms tend to reduce the risk by requesting assistance from external companies for development purposes.

Out of the total number of firms that participated in the research, 12 firms underwent an in-depth review, and case studies were developed which describe their eco-innovation. The case studies underlined some of the profiles of innovating firms: 1) firms whose international parent companies requested them to continually improve their environmental performance and to implement eco-innovation; 2) firms which encountered environmental problems and whose search for a solution led them to create an organizational unit which subsequently became the catalyst for eco-innovation projects; 3) firms which implemented eco-innovation due to economic pressures and the need for greater business efficiency; 4) firms which initiated eco-innovation projects as a result of the establishment of a new firm or the relocation of an existing firm to a new site.

The case studies demonstrated the significant improvement that has occurred over the years in the environmental management culture of the firms investigated.

The firms moved from environmental compliance "against their will" to a readiness to reduce environmental risks within the framework of a business strategy based on improved efficiency and improved business conduct. Some of them totally changed their environmental perception and today implement eco-innovation projects based on a true belief in the importance of environmental protection. Environmental regulation and enforcement constitute the legal base for the firm's activity. Regulation and enforcement leave the firm little room for flexibility and serve as a lower threshold for the environmental performance of the firm. It is important that this base remain. However, the findings of the research demonstrate that the factors which influence eco-innovation are layered in a kind of pyramid: at its base, legal requirements, in the middle economic/business requirements (such as the possibility of reducing expenses or requirements by clients, which leave the firm with limited flexibility and which are influenced by the environmental benefit of innovation to the firm), and at the top level reputation and environmental awareness – allowing for maximum flexibility by the firm. The influence of these factors is cumulative and increases the will of the firms to conduct eco-innovation.

It was also found that the readiness of the firms to implement eco-innovation is dependent on the stage of the production life cycle of the firm. When a new firm or a new production line is planned, or when a firm plans to relocate to a new site, it is easier and more economical to undertake eco-innovation. This may be likened to the state of "clay", which is amenable to kneading and to change – as in the planning stage of a firm or new production lines, compared to the state of "pottery" which is no longer capable of change – as when production lines have been established and are in operation. At the "clay" stage, when the firm plans its future production lines, it can integrate infrastructure for eco-innovation in these lines, which will enable it to implement the innovation in the future at a lower cost (introducing an element of "clay" into the "pottery"). However, in order to prepare such an infrastructure, the firm has to be aware of changing environmental needs and anticipated future regulation. Therefore close contacts with environmental authorities (Ministry of Environmental Protection) are necessary at the stage of planned changes in the firm. Today, firms are obliged to make contact with environmental authorities when they apply for a business license. However, conditions in a business license are generally formulated after the firm has already been constructed, when its capacity for change is limited.

Another way to encourage eco-innovation is to assist companies which develop eco-innovation solutions. This field includes a sector of external companies which specialize in the supply of experts, technologies, raw materials and technological solutions which enable firms to reduce their environmental impact. This supply of eco-innovation facilitates the easy and quick transfer of knowledge and environmental technologies and decreases the risk that the innovations will not comply with environmental standards or will fail technologically. The findings of the research show that in Israel this sector is largely based on the transfer of technologies and the development of incremental eco-innovations. Technology transfer has major importance in a small state such as Israel in reducing the technological gaps between Israel and leading countries worldwide. However, periods of radical environmental technologies occur around the world, as in the case of developments in the field of catalytic converters for vehicles, photo-voltaic cells and combined cycle gas turbines for electricity production. The development of such ground-breaking sectors allows the state to benefit economically from the environmental improvement, from the industrial production of this sector and from export.

In addition to the research carried out in the firms, a survey was conducted which reviewed nine industrial support programs and their potential support of eco-innovation. The results of the survey demonstrate that there is neither coordination nor synergy between the different programs, that they do not incentivize eco-innovation in industry and that environmental criteria are not included in their decision making process. At the same time, this situation may easily be remedied, since most of the programs are operated within the framework of two government ministries which can coordinate their work. The Organization for Economic Cooperation and Development (OECD) stresses that its members should promote eco-innovation and invest efforts in improving their efficiency in resource utilization. It is reasonable to assume that during its accession process to the organization, Israel will be required to make significant changes in these fields and early adaptation will be beneficial for the country

The research proposes the following recommendations : 1) improved coordination between the government ministries involved in eco-innovation, especially the Ministry of Industry, Trade and Labor and the Ministry of Environmental Protection; 2) change in the mix of environmental regulation –

increasing the share of economic tools and reducing the share of emission standards; 3) granting direct government support to eco-innovation projects in industrial firms; 4) harnessing existing government programs to support knowledge and improve technological capacities to implement eco-innovation and incorporate environmental considerations in the decision making process of these programs; 5) establishing a center for the validation of environmental technologies and for assistance to companies specializing in the development and supply of environmental solutions; 6) granting incentives and direct assistance to companies which offer environmental solutions to industrial firms; 7) promoting business solutions for the transfer of environmental responsibility from industrial firms to the suppliers of environmental technologies; 8) concentration of environmental authorities on the planning stages of new firms and production lines, transparency of forecasts of future environmental requirements which the authorities may impose on the firm and requirements that the firms submit their responses to these obligations. This will allow industries to prepare the infrastructure for future eco-innovation at the planning stage of a new firm.

TABLE OF CONTENTS

1. Introduction
 - 1.1. Industry and environmental quality in Israel
 - 1.2. Regulation, licensing and environmental enforcement
2. Eco-innovation: market and market failure
 - 2.1. Environmental solutions – demand and supply and the development of an eco-innovation market
 - 2.2. Government failure of eco-innovation
3. Eco-innovation – classification and examples
 - 3.1. Definitions of eco-innovation in the research study
4. Eco-innovation in Israel – research
 - 4.1. Research methodology
 - 4.2. Eco-innovation – state in Israel
 - 4.3. Factors influencing eco-innovation – statistical findings from the quantitative study
 - 4.4. Findings on the market failure of eco-innovation
 - 4.5. Summary of findings from the quantitative study
5. Eco-innovation at the firm level – case studies
 - 5.1. Background and research method
 - 5.2. Summary of case studies and discussion
6. Classification of the potential of contribution of public assistance programs to eco-innovation
 - 6.1. Analysis of government policy
7. Conclusions
 - 7.1. Importance and contribution of eco-innovation
 - 7.2. Policy of promoting eco-innovation

8. Bibliography

9. Appendices

Appendix 1: Definitions and examples of projects in the research study which are not considered as eco-innovation

Appendix 2: Case studies reviewed in Israel

1. Teva Pharmaceutical Industries Ltd.
2. Makhteshim
3. Carmel Forge Ltd.
4. Israel Aircraft Industries
5. Goldex
6. Intel Electronics
7. AVX Israel
8. Israel Electric Corporation
9. Steelcoat
10. Carmel Container Systems
11. Nesher Israel Cement Enterprises
12. Tambour Ecology (GES)

Appendix 3: Government Assistance Programs

Appendix 4: Telephone interviews with managers in firms

Appendix 5: List of meetings and interviews conducted, in addition to interviews in firms

Appendix 6: Statistical results of the quantitative study

Appendix 7: Number of eco-innovation projects and their budget by year

List of tables