The role of regulations in the diffusion of environment technologies: micro and macro issues

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Keywords

Technology transfer, Diffusion, Environment, Technology, Turkey

Abstract

Analyzes the impact of regulations on the process of the diffusion and development of environment technologies from the perspective of both firm and technology policies. Based on a case study in the Turkish fertilizer industry, observes that regulations and public pressures are the main determinants both in the transfer and in the diffusion of environment technologies, indicating the importance of the institutional infrastructure, namely the interplay among firms, government and non-governmental organizations. Thus, attempts to integrate the findings of the study and concludes with some technology policy issues both at the micro and macro level.

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This paper aims to analyze the role of regulations in the diffusion of environment technologies. Even though environment regulations and standards have been influential in the adoption of environment technologies in almost all advanced countries, there is still a debate about the role of regulations in the diffusion and development of environment technologies. According to one view, the main dynamic behind the development and diffusion of environment technologies is regulations and standards enforced by government, while another view considers that regulations cause distortions in the natural development and diffusion of technological innovations. The debate stimulates many empirical studies in understanding not only the role of regulations, but also the determinants that affect the effectiveness of regulations. This paper attempts to understand the role of regulations in the adoption of environment technologies in developing countries. By studying the Turkish fertilizer industry as a case, we exemplify how firms adopt environment technologies and how effective the regulations are. Then, we aim to understand under what conditions regulations can be effective in stimulating technological innovations.

The report has four sections. The first section will introduce the theoretical discussion about the relationship between regulations and environment technologies. Then, the second section will briefly introduce the empirical study conducted to analyze the impact of regulations on environment technologies in the fertilizer industry. The third section will present the micro and macro level analysis of the Turkish fertilizer industry. By analyzing the case study firms, we will discuss the dynamics in the diffusion of environment technologies. The final section will summarize policy conclusions arising from our study that might increase both the efficiency of the environmental regulations and the diffusion and development of environment technologies in developing countries.

Regulations and environment technologies

Technologies do not easily diffuse in industries. In general, the use of new technologies is expected to increase by time due to different reasons (Rogers, 1995). One

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model of technology diffusion is the epidemic model, indicating that the lack of information available about the new technology can limit the diffusion of technology. Another model, the probit model, suggests that different firms adopt new technology at different times due to their differences in goals and abilities. An alternative model is related to density dependence that considers diffusion as the result of legitimation and competition. Besides these models, recent studies increasingly highlight the absorption differences arising from the institutional variables such as regulations and science policy (Hultberg *et al.*, 1999; Burton and Hansen, 1993). Like any new technologies, the diffusion of environment technologies is also under the influence of many factors, ranging from firm-based reasons to institutional ones, particularly regulations (Porter and Linde, 1995).

Among different dynamics behind its diffusion, environment regulations and standards enforced by governments have a special role. Why are regulations so important? It is widely known that without government intervention, firms and individuals may have no reason to take externalities, in other words external costs, into account, the costs that the polluting individual or firm imposes on other member, of society (OECD, 1997). In particular, the atmosphere and water systems may be treated as free methods for disposing of unwanted waste products, despite the fact that unrestricted pollution of the atmosphere, or of ground water, rivers and seas may impose costs on other firms or individuals. That is why public authorities intervene to restrict environmental pollution and its externalities by internalizing environment costs through regulations (Cropper and Oates, 1992). Regulations aim to affect the decisions about the level of production and consumption activities that give rise to pollution, about the choice of technology, the use of pollution abatement measures and the disposal of waste products.

Even though the majority of advanced countries have comprehensive environment regulations, their role on the diffusion of environment technologies has been under scrutiny (Kemp, 1993; Geiser, 1991). The literature identifies two opposing views on regulations. The first view can be called as "trade-off" where society is expected to gain while firms lose. This view expects declining competitiveness of firms due to extra costs incurred by regulations as well as productivity loss caused by distortion of firm resources into inefficient areas. Another argument is that environmental regulations restrict firms in their technological innovations by some stringent environment control criteria (Kemp, 1993; Jaffe and Palmer, 1996). The second view, "win-win" view, considers regulations as a source of technological innovations that bring advantages to companies as well as society (Porter and Linde, 1995; World Bank, 1992). The win-win view accepts that regulations have a cost but the innovations created by regulations offset the costs incurred by regulations.

Empirical and theoretical studies cannot resolve the debate since studies find conflicting results. Neither the win-win proponents claim that all environmental regulation, whatever its form or strictness, leads to increased innovativeness and competitiveness, nor the trade-off view denies the possibility that in some cases it may be possible to obtain benefits in terms of both environment and innovativeness. Therefore, recent discussions have transformed into the understanding of the conditions under which environmental regulation increases or reduces innovativeness and hence leads to competitiveness (Jenkins, 1997; Geiser, 1991). These studies indicate that in the past the regulations have focused on pollution-control/end-of-pipe technologies rather than pollution-preventive/cleaner technologies. The new practice increases innovative capacity in firms due to the shift of focus to environmental improvement of processes, products, housekeeping, and materials handling (Bartzokas and Yarime, 1997).

This debate is important not only for advanced countries, but also for developing countries. Similar to the expectations in advanced countries, the diffusion of environment technologies can result in four main advantages for developing countries (UNCTAD, 1994; West and Senez, 1992; Jenkins, 1997; World Bank, 1992). First, the application of environment technologies requests re-examination and reconsideration of the products and the whole production process that can lead into process and product innovations. Second, environment technologies will reduce waste of all inputs including raw materials, skills, and energy.

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This, in turn, can result in two important benefits: decrease in production costs and increase in productivity. As developing countries are short of many inputs, their efficient use is of great importance to these countries. Fourth, application of environment technologies can also contribute to quality improvements of products. Fifth, firms with environment technologies will manage to increase their competitiveness and increase their export potential. It is important to remember that international environment standards are increasingly enforcing developing countries to comply with global rules in order to assess global markets. If developing countries neglect environment issues and do not adopt the eco-labelling practices and the international environmental management standards such as ISO 14000, their competitiveness will decrease and they will fail in exports, consequently hindering their economic development.

The empirical study: the Turkish fertilizer industry

In order to understand the role of environment regulations in the diffusion of environment technologies, we conducted an empirical study. The reason behind the selection of the fertilizer industry is the fact that it is one of the highly polluting sub-sectors of the chemical industry (IFA, 1996). This mature industry is a large-scale, energy-dependent, and capital-intensive industry. While the components of finished fertiliser products are relatively simple chemicals, the production technologies used are highly developed. There are three main types of fertilizers:

(1) ammonia nitrogen;
(2) phosphate; and
(3) potassium fertilizers.

In recent years, the fertilizer industry has been undergoing a restructuring and rationalisation process (Bartzokas and Yarime, 1997). Plants have been shut down and large investments have been made to improve efficiency and productivity in the use of energy as well as to increase quality of fertilisers.

Environment technologies are two types:

(1) end-of-pipe technologies; and
(2) cleaner technologies.

In the fertilizer industry, the former one includes pollution control techniques such as gas scrubbers, incinerators, and dust collectors, while the latter one refers to techniques such as new production technologies in phosphoric acid production (Bartzokas and Yarime, 1997). An example for a clean technology is the application of the recovery of fluoride and the total recycling of all off-gas and scrubbing water in the production process of superphosphates that reduced the discharges of pollutants from superphosphate production to almost zero (Bartzokas and Yarime, 1997).

The fertilizer industry supplies an important input to agriculture, the driving industry of the majority of developing countries. However, not many developing countries can have production due to high capital investment needed. As Turkey is one of the few developing countries that has established its fertilizer industry, the study is conducted in Turkey.

Briefly, we can introduce the Turkish fertilizer industry as follows. The Turkish fertilizer industry has altogether six large-scale inorganic fertilizer firms. Production in fertilizers has been experiencing high growth since 1962: increasing by 23 per cent per year during 1962-1972, 18 per cent during 1973-1978, 16.7 per cent during 1979-1984, and 6.5 per cent during 1985-1989. In the 1990s, the fertilizer industry experienced ups and downs with an annual growth rate of 4.5 per cent in the period of 1996-2000 (SPO, 1996). Turkish fertilizer production corresponds to 1.3-1.4 per cent of the total world production (AFP, 1998), that is far below the main fertilizer producing developing countries' output such as China, whose share in world production is 21.7 per cent. Turkey also fails in using fertilizers in comparison to advanced countries. In terms of consumption, the use of fertilizer per hectare is 83.6kg and it is lower than the world average of 95.2kg (Paramatik, 1997).

In this study, the impact of environmental regulation on production and technological change is investigated in depth by interviewing all Turkish inorganic fertilizer producer firms (see Table I). The Turkish fertilizer producers were established in the 1950s, 1960s, and 1970s as shown in Table I. Their production technologies have not been renewed since then. Only two firms have expanded their production and had new

Table I Establishment years, products, capacity, output, capacity utilization, and employment of the case study firms

Firm	Establishment years	Products	Capacity, ton/year	Output (1997)	Capacity utilization	Employment
F1	1954, 1961, 1976, 1978, 1989	TSP, compose, phosphoric and sulfuric acid	870,000	489,801	67.9	733
F2	1973, 1980	AS, TSP, DAP, compose, phosphoric and sulfuric acid	759,500	543,188	58.5	422
F3	1962, 1968, 1970, 1971, 1973, 1980	AN, NSP, DAP, ammonia, TSP, compose, phosphoric and nitric acid	1,699,700	991,993	68.7	4,677
F4	1978	DAP, compose	490,000	117,776	34.3	160
F5	1977, 1993	Urea, compose, ammonia	661,000	674,289	96.0	722
F6	1972, 1981, 1986	DAP, compose, AN, sulfuric and nitric acid	1,402,500	954,467	64.1	848

production technologies in the last decade, one in 1989 and another one in 1993. Out of six fertilizer firms, three firms (firms F1, F3 and F5) are public and the other three firms are private. State-owned plants constitute 60 per cent of all production and 82 per cent of all employment in the sector, and thus the government has a significant role in the industry. The product range of fertilizer firms are Ammonia, AN, AS, compose, DAP, NSP, TSP, Urea, and phosphoric and sulfuric acid. The capacity utilization in the industry is 65 per cent overall.

The fertilizer producers do not have modern production technologies; what about environment technologies? It seems that although environment regulations could not affect how production is done, it has enforced firms to invest in waste treatment utilities. Firms have started to invest in water treatment and in air emissions' cleaning systems in parallel with the establishment of environment laws. The majority of firms (four out of six firms) have invested in wastewater treatment systems for industrial water use in 1994. Also all firms invested in waste cleaning systems both in 1988 and in 1994. The major investment of all six firms was in air emission cleaning systems in 1994.

The micro and macro level analysis of the empirical study

When we asked our case study firms the reasons why they invested in environment technologies, we observed that all firms are motivated by regulations. Half of the firms incorporated environment technologies as embedded in their new expansion investments. Because of regulations, they chose environment-friendly production technologies in their new units. Similarly, during the expansion investments, firms renewed or invested in some waste treatment systems too.

In addition to regulations, public protests were effective in pushing half of the firms to consider investing in environment technologies. For example, when the colour of the sea around firm F2 has changed to a large extent and the products of farms in the region have burned, local environment groups have increased their voice. Firm F2 purchased many farms around its plant but still the protests continued. This led the firm to invest in waste disposal system that eliminated waste disposal to the sea. The management proudly asserts that only a few European firms have such a biological technology in their plants.

In short, our case study results show that firms invested in the environment mainly due to regulations that are enforced by the local authorities, followed by public pressure. This result shows that environmentalist groups and public organizations can play an important role, particularly as an enforcement of the environment rules and regulations.

None of the firms has a complete pollution prevention system at the firm level, rather partial systems at their different production units. Firms start to invest in cleaning and treatment technologies for their most polluting production units so that they can decrease their pollution to acceptable limits.

As firms are not eager to invest in new equipment or change their production, almost all environment investments are end-of-pipe technologies rather than pollution-preventive/cleaner technologies. We observed only three

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firms adopting pollution-preventive technologies for some of their production units, but these firms had new enhancement investments. Additionally, four firms (firms F1, F3, F5, and F6) received financial support from the World Bank for their energy transformation from fuel oil to natural gas. These investments brought the complementary environment investments that are basically related to water consumption and air emissions.

As the majority of investments serve pollution cleaning purpose, investments consist of emission cleaning systems and water saving technologies. However, none of the investments consists of solid waste treatment, since regulations concerning solid waste are not prepared yet for the fertilizer industry. All firms having solid waste stack them on open land at their production site.

It was clear from interviews that none of the producer firms (including state-owned ones) are willing to invest in clean technologies unless they are forced to do so. In areas where the local authority is active and forces firms to comply with regulations, firms take action. This was clearly observed by the behaviour of firm F1 that stopped its phosphoric acid production in Izmit where local authorities are strong in implementing regulations, while it kept its production in another plant where local authorities are weak.

How regulations were effective in determining firms' investment behaviour can be also observed by analyzing their attitude towards environment management. Regulations do not bring any requirement to set up environment management; none of the firms have environmental statement/report, environment management systems, environment standards (ISO 14000), and environment cost accounting. Except two firms, F2 and F3, firms do not have environment training either. Further, the majority of firms fail in auditing. Two firms (firms F2 and F5) mentioned that they had environment auditing for their production, but only one (firm F2) of them put the results of auditing into action when it invested in its wastewater treatment unit.

At the firm level, only three firms (firms F4, F5, and F6) mentioned that management has a concern for environment. Among these three, only firm F4 talks about a broader environment concern that includes production activities. This firm is even involved in a special environment program organized by the Chemical Producers' Association. Firm F5 has no environment policy, but it markets its product as environment-friendly, since the product by its nature pollutes land less than other fertilizers. Firm F6 is basically concerned with costs resulting from wastes and aims to decrease waste in order to reduce costs.

The overall analysis of firms' management practices reveals that they do not have any formal environment policy at the firm level. But more importantly, many of them do not plan to have environment policies either. As Turkish fertilizer firms tend to respond only to regulations, the starting point for any policy should be to restructure regulations that will enforce managers to be innovative. In additon, management culture needs to be changed. This, however, necessitates not only training of firm management on environment issues, but also increasing customer pressure that will demand environment-clean products. In the case of fertilizers, farmers who have a low education level could be a problem. That is why government's agricultural policy might play a crucial role in forcing fertilizer firms from the demand side.

Fertilizer firms' limited response to regulations and their neglect of environment policies could be explained mainly by the industry's being local. In other words, these firms produce for local markets and they do not face large competition at the local market. The EU producers are not competitors since they do not have cost advantage over Turkish producers because of their import dependence for inputs, similar to their Turkish counterparts. The majority of potential competitors are far enough away so that when transportation costs are added, they cannot compete fiercely with local firms.

Half of the firms, F4, F5 and F6, indicated that they would like to export but none of the firms are successful in exports. One reason for this is the fact that the Turkish fertilizer firms have low competitiveness due to their old technologies. Another reason is the existence of a large local market. Many firms indicate that they cannot even supply local demand that has a large potential of growth in future due to a new dam project whose completion will increase fertilizer demand by 25 per cent.

As a final remark, why firms fail in investing in environment technologies could be also explained to a lesser extent by the weak

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supply market. We see that an industry for the environment technologies is in its development process in the 1990s. In terms of technology suppliers, Turkey has no environment technology producers yet. So, Turkish fertilizer producers import their technologies, particularly from Germany. The existing technology firms are mostly technical service providers such as construction and design firms. There are also some firms supplying machinery parts used in environment equipment. When this market matures with a supply of a range of options for fertilizer firms, there might be more investments due to increased awareness and availability of environment technologies.

Conclusions

Based on two realities, namely high population that grows rapidly and a high ratio of employment (42 per cent of total employment) in agriculture, it is obvious that Turkey needs to have a fertilizer industry in order to supply fertilizers, one of the most important inputs for agriculture. However, it must also keep its environment sustainable. Then, the question is how to manage the diffusion of environment technologies in the fertilizer industry, one of the most polluting industries (SPO, 1996).

The Turkish example shows that regulations were the main factor in the diffusion of environment technologies, but the resulting effect of the regulations was very limited in terms of innovativeness and competitiveness of the fertilizer firms. This is to a large extent due to the existing structure of regulations that direct firms to invest in end-of-pipe technologies that are focused in pollution cleaning rather than pollution prevention.

If we attempt to generalize from this example, we can suggest that regulations need to be innovation oriented. Developing countries should not fall into the shortcomings and failures of 25 years of pollution control regulation that are focused only on pollution cleaning technologies (Geiser, 1991). Based on the suggestions of our case study firms and organizations, we raise some of the important actions that need to be taken to improve the diffusion of environment technologies so that innovations in the fertilizer industry will be stimulated to reduce waste and increase both quality and exports. These policy suggestions can be grouped under three headings: firm strategies, technology policies and environment policies.

Firm strategies

If firms want to benefit from the advantages of environment technologies as suggested in the win-win view, they need to follow a number of proactive and long-term strategies. First of all, instead of focusing on short-term solutions and purchasing end-of-pipe technologies that can only be used to comply with pollution levels, firms can consider environment regulations as an opportunity to analyze their production processes and efficiencies. Product and process innovations might end up with better products and processes in terms of quality and profitability as well as environmental protection.

Firms should integrate environment strategies with their investment decisions (Welford, 1995). During initial and enhancement investments, firms should pay attention to purchasing equipment and production processes that have environment control embedded into the system. Another point with firm strategies is related to the adoption of environmental management tools. Studies show that improving management and organization of production with environment concerns *per se* might result in substantial gains. For example, without any substantial investments in equipment, opportunities for energy conservation in the industrial sector in developing countries are estimated at 10-30 per cent (UNCTAD, 1994). These improvements are the result of environment management that includes development of environmental auditing and reports, employee training for environment practices, adaptation of environment standards (ISO 14000), and performing environment cost accounting.

Technology policies

The market for clean-technologies and cleaning technologies is in the formation process in Turkey. At the moment, there are few local technology producers. By the beginning of the 1990s, many technology supplier firms had been established and they, in most of the cases, transfer technologies, either buying licenses or becoming affiliations of foreign companies. After this initial process, as some examples show, it is possible

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that Turkish firms could start to produce their own technologies. In this regard, technological policies should be formed specific to the creation, diffusion, and implementation of environment technologies.

Some suggestions may be as follows. First, the technology policy should support small environment firms, not only to import, but also to develop environment technologies. While supporting technological developments, it is important to balance incentives for both end-of-pipe and pollution-preventing technologies. Second, from the demand side, government should induce incentive programs and subsidies for firms that adopt cleaner technologies (OECD, 1995). Third, there should be certainly more support for environment research at universities and public institutions. Finally, the diffusion of technology necessitates not only investment in hardware but also practising new management practices. That is why government can act as an information broker that supplies information on technology applications. Through universities, public institutions, and the help of voluntary organizations, government can train a firm's management on issues regarding technology transfer and technology applications. The success of Germany in terms of diffusion of environment technologies can be attributed to the creation of institutions that spread innovation widely throughout economy, particularly to the appropriate technology users (Burton and Hansen, 1993). As a result, industry's efficiency is increased and the cost of accessing and utilizing information is reduced. Developing countries might follow a similar strategy.

Environment policies

Governments must take a leadership role in creating a policy framework to increase the demand for cleaner technologies and products (Porter and Linde, 1995; OECD, 1997). Examples from developing countries show that political, social and economic stability, together with the creation of the necessary infrastructure, are important preconditions for technological change for sustainable development (OECD, 1994). Environment agencies in developing countries may be successful in terms of preparing regulations and standards, but they need to pay attention to a few points:

- First, political commitment at a high level is essential for success. Environment agencies should show their power and will for the application of its regulations. Unless long-term commitment is made, firms might not comply with regulations.
- Second, regulations do not work without control and punishment mechanisms. Problems related to institutional overlaps between and across different levels of government should be solved to have clear and consistent environmental goals and targets. Regulations should be applied equally to all firms to gain confidence among firms that control and punishment work for all violators.
- Third, some new methods could be developed to increase compliance with regulations and the adoption of cleaner technologies (OECD, 1995). For example, instead of punishment of the polluter, government can subsidize and give incentives to non-polluters for their technology investments. Similarly, education of customers and public is important to create a large public awareness for environment issues.
- Fourth, environment policies should be integrated by considering linkages. For example, the suppliers of inputs such as fuel or phosphate rock should be regulated as much as the fertilizer industry itself, since when these inputs have low environmental quality, then production will lead to pollution as observed in the case of our two case study firms. Another important linkage should be supplied in complementary industries such as agriculture and fertilizer industry. Without having a proper understanding of linkages among industries, it would be difficult to solve environment problems.
- Fifth, government agency should consider a mix of environment policies such as having fertilizer taxes that are highly recommended policy for developing countries.
- Finally, government should increase its cooperation with non-government institutions as well as international institutions. Non-government institutions raise the environment consciousness, so government should support the activities of these organizations and collaborate with them in preparing regulations and implementing them. By initiating

university-industry co-operation, it could be possible to address environmental technology issues through a series of seminars with groups from universities and environment agency staff. Similarly, international organizations are other sources where government can benefit a lot, especially getting informed about the recent developments in environment technologies and regulations. The best example is the contribution of the World Bank to fertilizer firms in the second half of the 1980s that helped to transform these firms' energy systems into natural gas, resulting in reduced air emissions in these firms. Moreover, UNIDO and UNEP have launched a program to support national cleaner production centers in some 20 countries for a five-year period (OECD, 1995). Developing countries might join to these centers and exchange their experiences. There are also national information centers that facilitate linkages between technology producers, traders and users.

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