STRATEGIC ENVIRONMENTAL TYPES AND OBSTACLES TO THE ABSORPTION OF CLEAN TECHNOLOGIES – THE CASE OF POLAND

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Abstract: The adoption of a cleaner production approach to environmental protection has generated the need to identify obstacles affecting the absorption of clean technologies by enterprises with different strategic environmental types in Poland. This research analysis focuses on a sample of industrial firms representing the following industries: food, fuel and energy and chemical. Findings indicate that there are statistical differences between the types of environmental strategies related to the influence of financial and legal obstacles to the absorption of clean technologies. The study also shows that the influence of obstacles on proactive environmental strategies was found to be smaller than on strategies with a lower level of adaptation.

Keywords: strategic management, clean technologies, absorption, obstacles.

1. Introduction

Since the early 90s, evolution of firms' environmentalism from end-of-pipe technologies towards clean technologies in controlling and reducing fossil fuel emissions and potentially limiting climate change has been observed (Acemoglu et al., 2016). Many solutions that determine enterprise response to the environmental protection regulatory changes are of a technological nature. The attitude of securing enterprise compliance with the law (reactivity) is extended with an interest in expensive "clean" environmental technologies, as a sign of anticipation of changes, which leads to predicting the environmental harmfulness risk. The risk anticipation is an antecedent of results of the negative enterprise effect on the natural environment. By extending the range of voluntary activities the enterprise responses to the requirements of market and non-market stakeholders, emphasising the role of new environmental technologies that prevent the pollution generation "at source" and activating internal resources in order to meet the surrounding requirements.

Many forms of environmentally friendly behaviours of firms are viewed as innovations, and, therefore, they should be interpreted from an absorption and diffusion perspective (Darley and Beniger, 1981). An absorption is an efficient absorption (acquisition) or acceptance by the enterprise, industry and economy of an innovation emerging on the market (Kaźmierczak-Piwko and Graczyk, 2012). A diffusion is the dissemination of an innovation within a social system. The diffusion theory focuses on how quickly and to what degree a social system accepts an innovation (Driessen, and Hillebrand, 2002). The absorption of clean technologies by an enterprise is associated with numerous conditions; therefore, it is justified to identify them and their influence on strategic environmental types of Polish companies. The aim of the article is to identify and assess obstacles to the absorption of clean technologies by enterprises in groups of enterprises with different types of environmental strategies.

2. Clean technologies and corporate strategic responses to environmental issues

Technologies are a strategic resource, co-deciding the market advantage of a company. Environmental technologies are divided into two groups: integrated and additive environmental technologies (end-of-pipe technologies). Integrated environmental technologies can be subdivided into product and process integrated measures, and these require reorganisation of the whole production process in companies (Figure 1). Searching for solutions preventing the emission of pollutants (dust, gas, sewage, waste, etc.) and the implementation of integrated environmental technologies seems to be a more beneficial solution than removing the effects of generated pollution through obsolete "end-of-pipe" technologies (Rennings, 2000; Baumgartner and Zielowski, 2007). The cost of developing a company's own technology is a much more capital-intensive undertaking than the absorption of environmental technology from outside an enterprise (Teece, 1977). The absorption of new technologies means acceptance of innovations that emerge as a result of the innovations' diffusion (Leszczyńska, 2011). Lanoie et al. (2011) argue that technology-based standards often impose the best available technology that already exists, providing little incentives for investment in R&D (Lanoie et al., 2011).

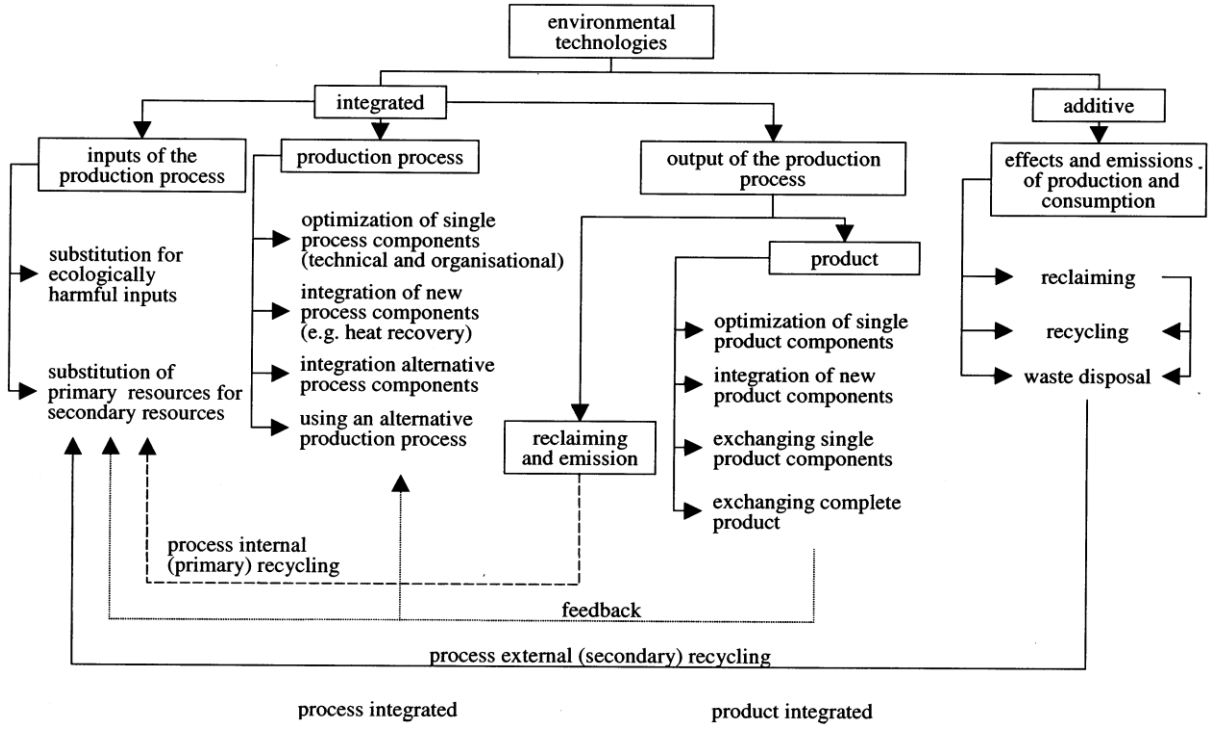

Figure 1. Preventive environmental technologies. Adapted from: Hohmeyer and Koschel (1995).

Enterprises may adopt environmental strategies from reactive to proactive ones as a result of external changes. Many solutions that determine the enterprise response to the environmental protection regulatory changes are of a technological nature. Constant monitoring of the legal requirements leads companies to explore pollution prevention options and to use clean technologies. Currently, a cleaner production approach, in other words a proactive approach, is characteristic for companies which adopt cleaner or clean technologies in products, processes and supply chains (Seroka-Stolka, 2014).

As technologies are a strategic resource, they can determine the strategic environmental types of firms. More studies present the classifications of environmental strategies based on continuum strategic possibilities. Henriques and Sadorsky (1999) consider four strategic environmental types – reactive strategy, defensive strategy, accommodative strategy and proactive strategy. Roome (1992) performs a classification of environmental strategies based on the reaction of firms to environmental management standards of the industries in which they operate. Roome (1992) also considers the passive environmental strategies of those firms that do not satisfy the minimum environmental requirements within the continuum. Reactive strategies are found at the next level of the continuum. Reactive environmental strategies represent a firms' response to compulsory environmental requirements and regulatory requirements (Murillo-Luna et al., 2008). Proactive environmental strategies are located in the most advanced positions of the continuum. These strategies are based on the use of the most advanced practices to prevent pollution, which have been defined by Sharma and Vredenburg (1998) as those strategies that go beyond the requirements specified by the regulation or by the normal practices of the sector.

In other words, when an enterprise only meets the regulatory requirements, then it is called a reactive environmental strategy, and when it voluntarily ("beyond regulation") extends them, it is recognised as a proactive environmental strategy (Dongwon, 2003; Darnall, J. Carmin, 2005; Aragón-Correa, 2007).

Garcés-Ayerbe et al. (2016) present the evolutionary model of strategies – from laggard positions with low intensity of environmental practices, to eco-innovative strategic positions characterised by high intensity of the adoption of environmental practices in different areas: production process, product, management and supply chains (Garcés-Ayerbe et al., 2016). Enterprises with proactive strategies are environmentally friendly and more eco-innovative than companies with less advanced strategies which adopt "end-of-pipe technologies". Enterprises with proactive environmental strategies voluntarily prevent pollution "at source" and use clean technologies, which goes beyond the legal requirements and environmental standards achieved by anticipating the most likely changes in the law. Anticipating the law requires early implementation, improvement or replacement of existing technology with new technology by enterprises.

Seroka-Stolka (2017) presents four different types of environmental strategies as follows: passive environmental strategy, reactive environmental strategy, attention to stakeholders strategy, proactive environmental strategy (Seroka-Stolka, 2017, pp. 236-237). This typology of environmental strategies is developed incrementally in an evolutionary process. It presents an evolutionary way to develop eco-innovations and was adopted in a research process. The initially dominant strategic attitude of securing compliance with the law is gradually extended with voluntary "beyond regulation" activities to develop clean technologies applicable in a given industry, business sector, region or country as a sign of legal regulation anticipation and meeting regulatory requirements. In summary, reactive and proactive environmental strategies of enterprises differ in the degree of minimisation of pollution and adoption of technologies "at source" to protect the natural environment.

3. Obstacles to absorption of clean technologies by enterprises

Clean technologies are regarded as the essential resource of ecological competitiveness (Buhl, 2016). Many research studies have confirmed that the adoption of clean technologies helps to protect the environment and contributes to a corporate green image or brand, as well as better performance and competitiveness of the firm (Ar, 2012). Companies that have decided to adopt or are in the process of implementing clean technologies should understand what existing obstacles and conditions may affect implementation of clean technologies. Nevertheless, there is no doubt that companies can develop their own environmental technologies that will be suitable for their production needs. However, external sources of

environmental technologies' absorption are considered as cheaper and requiring a shorter cycle of implementation, as well as lower business risk, for companies (Teece, 2003).

A general model of environmental technologies absorption presented by R. Kemp (1997) introduces technological and economic factors, as well as the environment conditions, that affect the effective acquisition and later implementation of environmental technologies by enterprises as follows:

- information channels,
- the scope and frequency of the information obtained,
- motivations for searching for information about environmental technologies.

The model also highlights the role of internal capabilities as learning capabilities. The level of the absorption of environmental technologies deepens on the information transfer system, the economic and technological nature of the technology and characteristics of the external environment (Kemp, 1997).

Scholars identify different conditions and obstacles relevant to eco-innovations as follows: environmental regulations, environmental standards (ISO 14001, EMAS), environmental R&D, environmental policy pressure, networking activities, quality/nature of industrial relations and process and induced costs, green culture, green information system (IS), infrastructure regulatory costs, absorptive capacity, stakeholders and culture, green organisational identity, corporate environmental ethics, green intellectual capital (Post, and Altman, 1994; Gluch et al., 2009; Qi et al., 2013; Chang and Chen, 2013; Chang, 2011; Chen, 2007).

However, some of the studies identify barriers and obstacles that prevent acquisition of clean technologies by enterprises with different types of environmental strategies. The first proposition of the classification of barriers, based on the strategic environmental adaptation of the firm, is the one proposed by Post and Altman. They distinguish between industry and organisational barriers. The industry barriers are as follows:

- high costs of the environmental investment,
- competitive pressures,
- regulatory constraints,
- information and technical knowledge.

High costs of the environmental investment are related to the acquisition of clean technologies to prevent pollution and implementation of Environmental Management Systems and often force firms to place priority on other types of investments in a situation when they are under high competitive pressure (Post and Altman, 1994). Post and Altman (1994) also indicate regulation restrictions and scarce flexibility in regulation compliance as barriers for changing the technological process and strategies towards cleaner production. Most of the authors emphasise that some characteristics of the command-and-control regulations promote the adoption of correction strategies rather than the prevention of pollution strategies by

implementation of clean technologies. Important obstacles are the lack of information about the potential results of absorption of clean technologies and access to technical knowledge.
The second proposition of the obstacles are organisational barriers as follows:

- employee attitudes,
- inadequate top management leadership,
- poor communication,
- past practices (Murillo-Luna et al., 2011; Shi et al., 2008).

Researchers often indicate the important barriers of clean technologies adoption as follows: organisational barriers such as employees' and top management's lack of commitment with the environment, limited training of employees, lack of organisational skills and qualification (Murillo-Luna et al., 2007; Zilahy, 2004). Moors et al. (2005) and Sandberg & Aarikka-Stenroos (2014) classified barriers of radical innovations as follows:

- economic barriers,
- systematic characteristics,
- knowledge infrastructure,
- legislative context,
- organisation and culture of the firm,
- stage of technology development (Moors et al., 2005, p. 663; Sandberg, Aarikka, Stenroos, 2014).

Moors et al. (2005) highlight that the organisational culture of the firm influences its environmental effects and preventive measurements and determines short-term thinking in production technologies (Moors et al., 2005). Furthermore, bureaucratic complexity related to legislation also represents a barrier that prevents environmental actions (Zilahy, 2004). Moors et al. (2005) point out that the availability of an extended firm-internal technology network including technical specialists is essential. Moreover, knowledge networks are necessary for the development and exchange of scientific and technical know-how about cleaner production methods. Therefore, it is justified to assess the influence of obstacles on absorption of clean technologies by enterprises with different types of environmental strategies. Hence the following hypotheses:

Hypothesis 1. *The effect of the influence related to the absorption of clean technologies by enterprises with a proactive environmental strategy is weaker in comparison to the environmental strategies of enterprises with a lower level of adaptation to the environment.*

Hypothesis 2. *There are statistical differences between types of environmental strategies related to the influence of obstacles on the absorption of clean technologies by enterprises.*

4. Research method and materials

The research was made on a total sample of 750 randomly chosen enterprises, based on the stratification criterion, from the following industries: food (40%), fuel and energy (36%), chemical (24%). Stratified sampling significantly increases the sample representativeness and reduces its error. A final sample consist of 180 firms, and the response rate is 24%.

A questionnaire survey was completed by management staff responsible for environmental management or production management. The four descriptions of environmental strategies (passive, reactive, attention to stakeholders, proactive environmental strategies) proposed by Murillo-Luna et al. (2008) and Seroka-Stolka (2017) were combined and used as an instrument to identify the types of environmental strategies. The respondents were asked to choose the most appropriate description of the environmental strategy if at least four of seven aspects listed in the questionnaire were suitable for their firms. According to literature, nine obstacles were chosen as independent variables and were measured through five-point Likert scales. The types of environmental strategies represented a dependent variable. Firms were asked to assess the obstacles, where the value 1 meant – "not at all important", and value 5 – "the most important" obstacle. To assess the influence of each of the obstacles influencing the absorption of clean technologies between the types of environmental strategies, the Kruskal-Wallis test and median test were performed. To indicate which groups of environmental strategies differ statistically, a post-hoc analysis was performed. The statistical verification of hypotheses was performed at three levels of significance: $\alpha = 0.05$, $\alpha = 0.01$, $\alpha = 0.1$. However, the maximum acceptable probability of making a type I error during the statistical verification of hypotheses was determined at $\alpha = 0.05$.

5. Results

The results of the self-classification indicate that 37% of companies chose a reactive environmental strategy, 35% of companies chose a strategy of "attention to the stakeholders", and 28% of the firms recognised a proactive environmental strategy. No company declaring the passive environmental strategy was identified. As a result, the sample consisted of three groups of firms with different environmental strategies (Figure 2).

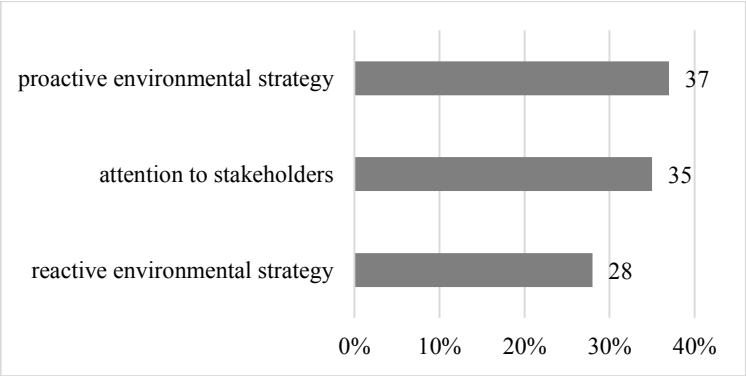

Figure 2. Types of environmental strategies in Polish companies (%). Source: own elaboration.

In order to compare three types of environmental strategies: reactive, attention to stakeholders and proactive environmental strategies, in relation to the influence of evaluated obstacles, the Kruskal-Wallis test and median test were performed (Table 1 and Table 2).

A significant effect of "limited access to external sources of financing investments in clean technologies (e.g. preferential loans, EU funds)" was confirmed both by the H test and the median test on the absorption of clean technologies between the groups of environmental strategies ($H = 10.46$, $p = 0.005$, $\chi2 = 13.48$, $p = 0.001$). A significant impact was also confirmed for the following obstacles: "lack of own funds to finance voluntary environmental investments for exchange of existing technologies for clean technologies" ($H = 10.27$, $p = 0.0059$, $\chi2 = 8.46$ $p = 0.014$), "high prices of clean technologies and services" ($H = 9.53$, $p = 0.0085$, $\chi2 = 8.50$, $p = 0.0086$) and "bureaucracy and complexity of environmental regulations" ($H = 5.70$, $p = 0.03$, $\chi2 = 5.90$ $p = 0.062$). However, the significant influence of "lack of information about the potential results of adsorption of clean technologies and environmental procedures" was confirmed by the H test ($H = 6.45$, $p = 0.039$, $\chi2 = 2.08$, $p > 0.05$), but it was not confirmed by the median test.

The results of the Kruskal-Wallis test indicate that the strength of influencing obstacles on the absorption of clean technologies by enterprises with a proactive environmental strategy proved to be significantly weaker than in the case of enterprises that adopted the strategy of attention to the stakeholders. In order to reach strategic proactivity, enterprises with a lower adaptation level have to overcome the legal requirements and financial obstacles related to the absorption of clean technologies first.

In order to assess which of the environmental strategies differ significantly in relation to the influence of obstacles on the absorption of clean technologies, post-hoc tests were performed (Table 2). Post-hoc tests revealed that differences between the types of environmental strategies are small and indistinct in relation to the influence of most obstacles. Post-hoc tests indicate that there are statistical differences between the following groups of environmental strategies:

- proactive vs. reactive strategy ($z = 2.46$, $p < 0.05$) and proactive vs. attention to stakeholders ($z = 2.35$, $p < 0.05$) for the "bureaucracy and complexity of environmental regulations",

- proactive vs. attention to stakeholders for "lack of information about the absorption of clean technologies and environmental procedures" ($z = 2.41$, $p < 0.05$),
- proactive vs. attention to stakeholders for "limited access to external sources of financing investments in clean technologies (e.g. preferential loans, EU funds)" ($z = 3.04$, $p < 0.05$),
- attention to stakeholders vs. reactive strategy for "high prices of clean technologies and services" ($z = 2.90$, $p < 0.05$),
- proactive vs. attention to stakeholders ($z = 2.580134$, $p < 0.05$) and attention to stakeholders vs. reactive strategy ($z = 2.77$, $p < 0.05$) for "lack of own funds to finance voluntary environmental investments (e.g. exchange of economically viable technologies for clean technologies)".

To sum up, the post-hoc analysis shows that there are some statistical differences between the types of environmental strategies for the influence of finical and bureaucracy and complexity of environmental regulations obstacles. The conducted research allows us to accept hypothesis 1 fully and hypothesis 2 in part.

Table 1.
Obstacles to the absorption of clean technologies. Comparing the types of environmental strategies – Kruskal-Wallis and median tests

Obstacles	A type of environmental strategy	Kruskal-Wallis test				Median test	
		Average range	Average median	H test	p-values	Chi-square test	p-value
Bureaucracy and complexity of environmental regulations	proactive	84.14	4	5.70	0.030	5.99	0.062
	attention to stakeholders	92.02					
	reactive	102.25					
High pressure from competitors in another business activity	proactive	89.20	3	0.08	0.95	1.07	0.58
	attention to stakeholders	91.85					
	reactive	89.20					
Lack of technical knowledge and information about the implementation of clean technologies	proactive	87.14	2	0.619	0.73	2.014	0.36
	attention to stakeholders	89.35					
	reactive	94.18					
Short-term planning	proactive	83.97	3	1.24	0.53	2.85	0.24
	attention to stakeholders	94.28					
	reactive	91.93					
Lack of information about the potential results of adsorption of clean technologies and environmental procedures	proactive	78.32	4	6.45	0.039	2.08	0.35
	attention to stakeholders	102.07					
	reactive	88.86					
Uncertainty of market results for the implementation of clean technologies	proactive	85.00	4	3.66	0.15	5.51	0.063
	attention to stakeholders	97.35					
	reactive	92.06					
Limited access to external sources of financing investments in clean technologies (preferential loans, EU funds)	proactive	87.77	4	10.46	0.005	13.48	0.001
	attention to stakeholders	105.42					
	reactive	75.58					
High prices (purchase) of clean technologies and services	proactive	90.05	4	9.53	0.0085	9.50	0.0086
	attention to stakeholders	112.17					
	reactive	76.45					
Lack of own funds to finance voluntary environmental investments (e.g. exchange of economically viable technologies for clean technologies)	proactive	81.67	3	10.27	0.0059	8.46	0.014
	attention to stakeholders	107.00					
	reactive	81.56					

Source: own elaboration.

Table 2.
Obstacles to the absorption of clean technologies. Differences between the types of environmental strategies – post-hoc tests

Obstacles	Differences between the types of environmental strategies	Z test	P value
Bureaucracy and complexity of environmental regulations	proactive vs. reactive strategy	2.466855	p<0.05
	proactive vs. attention to stakeholders	2.358780	p<0.05
	attention to stakeholders vs. reactive strategy	0.629729	p>0.05
High pressure from competitors in another business activity	proactive vs. reactive strategy	0.133352	p>0.05
	proactive vs. attention to stakeholders	0.138274	p>0.05
	attention to stakeholders vs. reactive strategy	0.289023	p>0.05
Lack of technical knowledge and information about	proactive vs. reactive strategy	0.225178	p>0.05
	proactive vs. attention to stakeholders	0.525691	p>0.05
	attention to stakeholders vs. reactive strategy	0.724149	p>0.05
Short-term planning	proactive vs. reactive strategy	0.819519	p>0.05
	proactive vs. attention to stakeholders	1.050975	p>0.05
	attention to stakeholders vs. reactive strategy	0.256477	p>0.05
Lack of information about the absorption of clean technologies and environmental procedures	proactive vs. reactive strategy	1.084986	p>0.05
	proactive vs. attention to stakeholders	2.419598	p<0.05
	attention to stakeholders vs. reactive strategy	1.439105	p>0.05
Uncertainty of market results for the implementation of clean technologies	proactive vs. reactive strategy	1.242284	p>0.05
	proactive vs. attention to stakeholders	1.768464	p>0.05
	attention to stakeholders vs. reactive strategy	0.576279	p>0.05
Limited access to external sources of financing investments in clean technologies (preferential loans, EU funds)	proactive vs. reactive strategy	1.254257	p>0.05
	proactive vs. attention to stakeholders	3.040337	p<0.05
	attention to stakeholders vs. reactive strategy	1.923760	p>0.05
High prices (purchase) of clean technologies and services	proactive vs. reactive strategy	1.709224	p>0.05
	proactive vs. attention to stakeholders	1.027430	p>0.05
	attention to stakeholders vs. reactive strategy	2.907927	p<0.05
Lack of own funds to finance voluntary environmental investments (e.g. exchange of economically viable technologies for clean technologies)	proactive vs. reactive strategy	0.011147	p>0.05
	proactive vs. attention to stakeholders	2.580134	p<0.05
	attention to stakeholders vs. reactive strategy	2.771021	p<0.05

Source: own elaboration.

6. Discussion

The research revealed the differences between the types of environmental strategies with respect to the influence of most analysing obstacles on the absorption of clean technologies, but financial and regulatory constraints proved to be statistically significant. Moors et al. (2005) also confirmed that the most important barriers of cleaner production technologies appear to be the cost of investment and the high risk involved in committing capital to unproven technology. The impact of bureaucracy and complexity of environmental regulations on the absorption of clean technologies significantly differs between two types of environmental strategies: proactive vs. reactive strategy and proactive vs. attention to stakeholders. Regulatory conditions have been identified as an important determinant of adopting clean technologies in several

empirical studies (Del Rio Gonzalez, 2005; Frondel et al., 2007; Long et al., 2016). Del Rio Gonzalez (2005) identified regulation pressure as one of the main drivers of adopting cleaner technologies in a survey in the Spanish pulp and paper industry (Del Rio Gonzalez, 2005). Frondel et al. (2007) highlight that the effects of environmental regulation may differ with regard to different environmental technology fields (Frondel et al., 2007). The core barrier which is identified by these studies is the financial cost of the technology or innovation placed upon the adopter. However, Frondel et al. (2004) argue that regulatory measures are not significant for the introduction of cleaner production technologies (Frondel et al. (2004). They explain that this results from the fact that cleaner production measures have been less subject to environmental regulations so far. Nevertheless, it is worth emphasising that regulatory barriers in some countries play a crucial role, because they place greater emphasis on climate mitigation. Long et al. (2016) confirm that high costs and long pay-back periods are important barriers to adoption of clean technologies. Moreover, they confirm that the diffusion process of clean technologies is still low, and the costs of the adoption of cleaner production technologies are still high (Long et al., 2016).

As a result of the study, it can also be concluded that there is a common tendency of the impact of the obstacles: the intensification of the impact of the obstacles was the largest among enterprises with strategies of attention to stakeholders and then decreased in the group of enterprises with pro-active environmental strategies. This may mean that enterprises with a strategy of attention to stakeholders first have to overcome the economic and financial constraints associated with the absorption of clean technologies to achieve strategic pro-activity. Similar research results were gained by Murillo-Luna et al. (2007) and Valero-Gil et al. (2017). They concluded that the greater the strategic proactivity level, the less influence of the barriers. Furthermore, they confirmed that major external barriers arise mainly from the high opportunity cost of environmental investment and from the bureaucratic complexity of the legislation, and these are related to their lack of financial capability (Murillo-Luna et al., 2011; Valero-Gil et al., 2017).

Access to financial resources is an important factor in the absorption of clean technologies. Limited capital leads to the creation of investment barriers. Capital remaining at the disposal of an enterprise is often shifted to priority investments. If environmental activities do not belong to them, it may be difficult or impossible to achieve more advanced environmental strategies.

7. Summary

This research study investigates the influence of obstacles related to absorption of clean technologies by enterprises with different types of environmental strategies – reactive, attention to stakeholders and proactive. The research study confirmed that financial and legal obstacles play an important role in the process of absorption of clean technologies by enterprises with different types of environmental strategies. However, further research is needed. The major limitation of the study is that the observations were collected from a single country sample. Moreover, the sample consisted mostly of big companies with proactive environmental strategies that usually have greater financial resources.

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