*Environmental Engineering and Management Journal*

*October 2014, Vol.13, No. 10, 2431-2436*
*http://omicron.ch.tuiasi.ro/EEMJ/*

*"Gheorghe Asachi" Technical University of Iasi, Romania*

# ATTITUDES TOWARDS ECO-INNOVATION IN THE CHEMICAL INDUSTRY: PERFORMANCE IMPLICATIONS

**Angela González-Moreno*, Francisco José Sáez-Martínez, Cristina Díaz-García**

*University of Castilla-La Mancha, Faculty of Economics, Department of Business Administration, 1 Plaza de la Universidad, 02071 Albacete, Spain*

## Abstract

Despite a growing literature on the importance of environmental activities for firms' strategies, there are still few studies aimed at analysing whether an environmental orientation has any impact on innovation performance. Firms within the chemical industry have a great concern for this subject, due to the larger impact that their decisions could have on the environment. This study focuses on the chemical industry and contributes important findings regarding the relationship between a firm's environmental orientation and its innovation performance. Through a logistic regression model our paper demonstrates the existence of this relationship and its relative importance in comparison with other strategic orientations of the firms (market and costs). The main contribution of this paper is that chemical industry firms with an environmental orientation improve their innovation performance, specifically regarding logistic systems and manufacturing processes.

*Key words:* chemical industry, environmental attitudes, innovation performance

*Received: May, 2014; Revised final: October, 2014; Accepted: October, 2014*

## 1. Introduction

Eco-innovation can be defined as the introduction of any new or significantly improved product (good or service), process, organisational change or marketing solution that reduces the use of natural resources (including materials, energy, water and land) and decreases the release of harmful substances across the whole life-cycle (EIO, 2011). The chemical industry is usually considered one of the most polluting industries. Ensuring safe production, transport and handling of its products, with care for the environment and in full accordance with regulations, is of key importance for the image and reputation of today's chemical industry (González-Moreno et al., 2013).

In an attempt to change this negative image, most chemical companies have engaged in the development and introduction of eco-innovations. This movement towards eco-products and processes has been driven by customers and industry associations. Consumers are becoming more aware and selective in purchasing products (Panainte et al, 2014). Besides, it has been recently found that normative pressures that come from the similar attitudes and approaches of professional groups and associations seem to be a key driving force for the development of eco-innovations in this industry.

"Culture, social norms and history in an industry seem to be powerful predictors of entrepreneurial activity and sustainable practices in the chemical industry. Together, customers and industry associations structure how important issues are perceived and appropriate actions are developed as firms in the chemical industry seek to show congruence with the institutional environment and thus gain legitimacy" (González-Moreno et al., 2013).

The acquisition, maintenance and development of a firm's capacities in order to keep

* Author to whom all correspondence should be addressed: E-mail: angela.gonzalez@uclm.es

up and speed innovations are keys to survival in nowadays competitive and global environment. These capacities depend on a firm's innovation objectives and the resulting innovation strategy (Burgelman et al., 2004), which is fundamental for succeeding in the innovation process. Its innovation objectives or orientation guide the firm in adapting, integrating and reconfiguring its technological and managerial resources and capabilities in order to make them suitable for competing in todays' global environment.

Following, Guan et al. (2009) call for investigating companies' perceptions of innovation strategies and their impact on performance, several authors has recently tried to analyse environmental orientation as a determinant of innovation performance (e.g. Sáez-Martínez et al., 2014). Our purpose is to follow this call and increase our understanding of the implications of eco-innovations in the chemical firms.

The research question we aim to answer is the following: What is the relative impact of environmental orientation of chemical firms on their innovation performance?

Traditionally, reducing costs and profit seeking are the main motivations for firms to innovate. Schumpeter (1934) stated that innovation is the driving force of progress and development and that the main incentive for firms to innovate is to capture supra-normal profits derived from temporary monopolies.

Nowadays, environmental concerns for innovation are becoming increasingly more common as firms are more aware of the consequences of their activities and attempt to be socially responsible.

This is motivated either by external pressures such as stricter governmental regulation and stakeholders (Horbach et al., 2012), or by the recognition that it can lead to a competitive advantage and increased performance through cost reduction and/or improved reputation (Mondéjar-Jiménez et al., 2010).

In the chemical sector, the search for legitimacy within society in general, means companies behave responsibly with the aim at improving the environment: reducing materials, recycling, or introducing changes to comply with the legislation and environmental regulations developed by the public authorities (González-Moreno et al., 2013).

Additionally, environmentally oriented innovations can generate competitive advantage through more efficient production (Petraru and Gavrilescu, 2010). Hence, innovation and environmental orientation are two concepts that have a separate impact on the firm's performance and that together act synergistically (Esty and Winston, 2006).

The analysis of these two concepts will allow us to comprehend how the balance between profit seeking and environmental orientation leads to better innovation performance.

Consequently, according to the previous arguments and with an exploratory aim, we propose the following hypothesis:

H1: The existence of an environmental orientation in a firm's decisions increases its probability of generating innovations.

In the following section we describe the data and the methods employed. Subsequently we discuss the main results and present the main conclusions.

## 2. Materials and methods

Our sample consisted of 444 companies from the Spanish chemical industry (excluding pharmaceutical companies), from which we obtained information regarding their innovation activities. Information was obtained from the Technological Innovation Panel (PITEC). A general description of the sample, including descriptive statistics can be found in González-Moreno et al. (2013).

Using this dataset we proceeded to carry out the following statistical analyses in line with the aim of the paper.

Factor analysis: Firstly, we carried out a factorial analysis to group the survey variables that enable us to identify different orientations in the innovation objectives of the firms. Three factors were identified. Subsequently, we included the factors as explanatory variables of innovation performance.

Logistic regression analysis (Logistic regression does not assume a linear relationship between the dependent and independent variables. The dependent variable must be a dichotomy (2 categories).

The independent variables need not be interval, nor normally distributed, nor linearly related, nor of equal variance within each group): With the aim of finding out if the environmental orientation of chemical firms affects its innovation performance we generated four models of logistic regression; one per each type of innovation according to its nature: product innovation, process innovation; logistic systems innovation and, finally, support systems innovation (models 1, 2, 3 and 4 respectively).

Logistic regression is an appropriate method when the dependent variable Y is dichotomic and the aim is to test relationships through a model of conditional probability *Pr(Y=1/X=x)* as a function of *X*. Logistic regression employs binomial probability theory in which there are only two values to predict that probability ($p$) is 1 rather than 0, i.e. the company belongs to one group rather than the other (Eq. 1).

$$p_i = \frac{1}{1+e^{-\left(\beta_0+\beta_1 x_{1,i}+.....+\beta_k x_{k,i}\right)}} \tag{1}$$

where "$p$" is the probability that a case is in a particular category and the "$\beta s$" are the coefficients of the predictor variables "$x$".

We included the three factors related to the orientation of innovation strategy in the logistic regressions. This enabled us to broaden our scope, not only by testing for the impact of environmental attitude on innovation performance, but also its relative effect in the dependent variables of innovation performance.

As stated previously, the dependent variables referred to the different natures of innovation performance: product innovation, process innovation, logistic systems innovation and support activities innovation.

With regards to independent variables, the orientation constructs obtained in the factorial analysis were included in the logistic regressions. The variables which enabled us to identify different orientations refer to motivations guiding innovation strategy (Table 1).

These were operationalized as the importance of each one of the motivations guiding innovation, using a four-point Likert scale from 1 (not at all relevant) to 4 (very relevant).

"Firm size" and "membership of a business group" were included as control variables. "Group" is a dummy variable that takes the value of 1 when the firm belongs to a group and 0 otherwise. "Size" is measured as the log of the number of employees.

Besides these, other explanatory variables related to innovation strategy, such as expenditure on innovation activities, were included: *acquisition of machinery and equipment* - including hardware or software to produce new or significantly improved products and processes*; acquisition of external knowledge*, - purchase or licensing of patents and non-patented inventions, know-how and other types of knowledge for the development of innovations; *Design activities*; *Personnel training expenses* related to innovation; and *Marketing activities* related to the introduction of innovations including market research and launch advertising. These are measured as dummy variables that take the value 1 when the firm has carried out each type of activity during the period 2006-2008. A summary of the variables included in the logistic regressions is provided in Table 2.

**Table 1.** Variables used for identifying innovation strategy

| ***How important were each of the following objectives for your activities to develop innovation during the three years from 2006 to 2008*** |
|---|
| Increase range of goods or services |
| Replace outdated products or processes |
| Enter new markets |
| Increase market share |
| Improve quality of goods or services |
| Increase flexibility for producing goods or services |
| Increase capacity for producing goods or services |
| Reduce labour cost per unit output |
| Reduce materials per unit output |
| Reduce energy costs per unit output |
| Reduce environmental impacts |
| Improve health or safety |
| Meet regulations or standards of environment, health or security |

**Table 2.** Variables

| ***Dependent variable:*** |
|---|
| Innovation performance<br>Model 1: Product innovation<br>Model 2: Innovation in methods of manufacturing or producing goods or services<br>Model 3: Innovation in logistics, delivery or distribution methods<br>Model 4: Innovation in support activities for company processes |
| ***Independent variables:*** |
| Control variables:<br>Group<br>Size |
| ***Orientation of innovation strategy:*** |
| Market orientation<br>Cost orientation<br>Environmental orientation |
| ***Expenditure on innovation activities:*** |
| Acquisition of machinery and equipment Acquisition of external knowledge<br>Design activities<br>Training for innovation activities<br>Marketing activities |

## 3. Results and discussion

We carried out an exploratory factor analysis using the principal component method as shown in Table 3 in order to identify the different orientations of Chemical firms' innovation strategy. For this analysis Kaiser's (KMO) and Bartlett's measures of sampling adequacy were used to measure the extent to which variables are appropriate for factor analysis (The KMO measures the sampling adequacy which should be greater than 0.5 for a satisfactory factor analysis to proceed (Kim and Mueller, 1978). We extracted three factors with eigenvalues greater than one via principal components analysis. Taken together, these factors explain 72 per cent of the total variance, a finding that leads us to conclude that they are a fair representation of the information underlying the 13 original items. This factor analysis shows that there are three underlying motivations for firms to innovate in the Chemical Industry.

The first factor represents the *market-orientation* of the firm, which introduces innovations in order to enter new markets, increase market share or just to increase the range of products or to improve their quality. Another motivation derives from the aim of the firm to reduce costs per unit output. We call this *cost-orientation*. Finally, we found out that reduce environmental impacts, improve health or even meet regulations or standards of environment is another motivation for firm to innovate. We call this orientation of the innovation strategy of Chemical firms, *environmental-orientation*. Similar dimensions were recently found in young SMEs operating in different industries (Sáez-Martínez et al., 2014).

Table 4 shows the results of the four logistic regression models carried out to test the relative impact of environmental orientation on innovation performance according to its nature: product, process, logistics and support activities.

**Table 3.** Factor Analysis

| *Orientation of Innovation Strategy* | *Factor 1 Market-orientation* | *Factor 2 Cost-orientation* | *Factor 3 Environmental orientation* |
|---|---|---|---|
| Increase range of goods or services | 0.816 | | |
| Replace outdated products or processes | 0.567 | | |
| Enter new markets | 0.800 | | |
| Increase market share | 0.840 | | |
| Improve quality of goods or services | 0.729 | | |
| Increase flexibility for producing goods or services | | 0.761 | |
| Increase capacity for producing goods or services | | 0.802 | |
| Reduce labour cost per unit output | | 0.840 | |
| Reduce materials per unit output | | 0.786 | |
| Reduce energy costs per unit output | | 0.812 | |
| Reduce environmental impacts | | | 0.807 |
| Improve health or safety | | | 0.835 |
| Meet regulations or standards of environment, health or security | | | 0.833 |
| KMO | | | 0.892 |
| Bartlett's' | | | 10858.55*** |
| Variance explained | | | 72.76 |

**** Sig. 99%*

**Table 4.** Logistic regression models (Wald coefficients)

| *Independent variables* | *Model 1 Product innovation* | *Model 2 Manufacturing process* | *Model 3 Logistics* | *Model 4 Support activities* |
|---|---|---|---|---|
| Constant | 4.883 | 1.739 | 82.896*** | 49.090*** |
| Size | 1.513 | 1.763 | 0.292 | 0.377 |
| Group | 0.013 | 0.302 | 0.164 | 0.114 |
| Cost orientation | 0.534 | 28.222*** | 16.506*** | 11.028*** |
| Market orientation | 19.738*** | 6.023** | 1.522 | 0.962 |
| Environmental orientation | 0.182 | 3.626* | 5.323** | 1.747 |
| Acquisition of machinery | 2.648 | 3.507* | 2.209 | 7.509*** |
| Acquisition of external knowledge | 0.219 | 0.061 | 0.026 | 0.103 |
| Design activities | 0.012 | 1.859 | 0.037 | 0.779 |
| Training for innovative activities | 0.808 | 4.308** | 0.034 | 0.339 |
| Marketing activities | 23.959*** | 0.800 | 4.561** | 5.327** |
| X2 Model | 104.354*** | 64.978*** | 39.457*** | 39.245*** |
| -2 Log likelihood | 413.819 | 547.614 | 360.642 | 512.647 |
| Nagelkerke | 0.304 | 0.182 | 0.143 | 0.119 |
| % correctly predicted | 75.9% | 65.5% | 83.1% | 69.6% |
| N | 444 | 444 | 444 | 444 |

The four models are significant and help to correctly predict more than 65 per cent of the cases.

Our findings indicate that firms which are more environmentally orientated will develop innovations related to manufacturing processes and mainly, related to logistics and distribution. In addition, we have observed that market-oriented chemical companies will be more likely to develop product and process (manufacturing methods) innovations. Furthermore, firms which are cost-oriented will be more likely to develop innovations related to manufacturing processes, logistics and support activities but not product innovations. Therefore, our hypothesis is confirmed for only two of the four models, since, although the coefficients are positive for all of them, environmental orientation is only significant for manufacturing process innovation (model 2, coef. 3.626) and for logistic systems innovation (model 3, coef. 5.323).

Model 1, in which the dependent variable is the likelihood of chemical firms engaging in product innovation, shows that both market orientation (19.738) and expenditure on marketing activities (23.959) are related significantly to the probability of firms introducing new products in the market.

Process innovation performance improves when firms have a market orientation (6.023), a cost orientation (28.222) and an environmental orientation (3.626), since the three variables have positive and significant coefficients. Furthermore, the acquisition of machinery and equipment (3.507) and expenditure on personnel training related to innovation (4.308) also contribute to firms achieving more successful process innovations.

Model 3, regarding logistic system innovation, is the one which demonstrates the greater importance of an environmental orientation in the likelihood of innovating (5.323 is the highest coefficient in comparison with the other models). Other variables that are related to a higher probability of introducing logistic changes are cost orientation (16.506) and expenditure on marketing activities (5.327).

Finally, the fourth model, which aims to explain innovation in support activities, indicates that only cost orientation (11.028) increases the probability of engaging in this type of innovation; which is also favoured by spending more on the acquisition of machinery (7.509) and marketing activities (5.327).

The logistic regression models enable us to investigate the relationship between environmental orientation and different types of innovation, observing the relative impact of this orientation in comparison with other strategic orientations such as market and cost orientations. Our findings indicate that an environmental orientation increases the likelihood of firms investing in processes and logistic systems. Both types of innovation (manufacturing processes and logistics) are traditionally related to activities which incur large costs, both in energy and materials. For this reason, these types of innovation are oriented towards a reduction in materials and energy consumption and a search for more efficient and environmentally respectful ways of producing. In short, their aim is to improve the environmental impact of the firm's activity.

## 4. Conclusions

The findings show statistically significant relationships between innovation performance and several independent factors related to R&D strategy expenses and the orientation of innovation strategy. The results of this study reflect the current process in which environmental concerns are being integrated into the conventional innovation paradigm.

Eco-innovation is assessed in this paper on the basis of environmental and social goals. Environmentally oriented chemical firms develop their product and process (manufacturing, logistic and support activities) innovations aiming to reduce materials and energy costs per unit output, minimize environmental impacts, improve health and safety or meet regulations or standards in environment, health or security. This orientation enters the core of the companies' business activities as they introduce innovations driving sustainable development. In this way, this focus on eco-innovations leads them to obtain better innovation performance, which can generate greater profits.

In practical terms, this study is a reminder to managers of the importance of nurturing a pro-environmental orientation in their innovation strategy and improving their sensitivity to stakeholders´ environmental demands. Traditionally, chemical firms mainly considered environmental issues in order to comply with regulations. However, our research shows that an environmentally-oriented innovation strategy helps these firms to improve their performance through achieving more process and logistic innovations.

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