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HOW FIRM VALUE REFLECTS GREEN INTELLECTUAL CAPITAL

The impact of green technological innovations and green marketing actions on firm performance

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How firm value reflects green intellectual capital.
The impact of green technological innovations and green marketing actions on firm performance

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Abstract

This paper focuses on the impact that the introduction of environmental technologies (i.e., less polluting process technologies or green products) and environmental marketing strategies have on the firms' market value. For a sample of US-based, large chemical companies over a period of 10 years (1999-2008), we first measure whether and how many environmental technologies have been developed, and then we assess whether and how our sample firms have undertaken marketing actions to promote their environmental concern. We employ innovative indicators to measure both dimensions. Finally, we estimate how those two dimensions affect firms' market value. Our results confirm that, taken alone, both environmental innovations and environmental marketing actions positively affect firms' performance. However, we show that when firms simultaneously develop environmental technologies and promote their technological results by means of marketing actions, the financial market misinterprets firms' overall environmental concern and, as a consequence, lowers firms' evaluation. From these results, we draw relevant managerial implications.

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1. Introduction

During the last decades, the ecological issue has assumed a growing importance, and the need to reduce pollution and to lower carbon dioxide (CO_2) emissions has become a key concern of many national and international policies. In turn, firms are required to respond to increasingly stricter mandatory market-based and information-based environmental regulations, and have more and more been involved in promoting voluntary proactive approaches to environmental protection. Besides regulations, other factors influencing the firms' behavior are market pressure and the greater attention that consumers are paying to the environmental impact of products and manufacturing processes. Within this scenario, one of the main requirements of firms' corporate social responsibility actions is that of introducing innovative, cleaner technological production processes and green products.

Against this background, the aim of the paper is to assess the impact of the introduction of environmental technologies, through an associated marketing action, on firms' financial performance. Specifically, we analyze the interplay between the introduction of environmental innovations – aimed at developing green products or cleaner process technologies – and the marketing promotion of those innovative investments. Then, we explore how environmental innovations and environmental marketing actions affect the firms' financial performance.

There are several reasons that make the topic of the paper worth of attention. First, by following a *corporate environmentalism* approach (among others, see Menon, 1997), during the last years firms have increasingly recognized the importance of environmental issues and, accordingly, have started to integrate those issues into their strategic plans, among which - marketing strategic plans (Banerjee *et al.*, 2003). Nevertheless, the effect of such strategies on the firms' market competitive position has not fully explored, and the impact on financial performance remains uncertain. For instance, a recent survey found that around 50% of surveyed consumers buy green products. Among those that do not purchase such products, the biggest impediment is the lack of awareness, which is mainly explained by the tendency that firms have to de-emphasize green communication for the fear of being accused of "greenwashing" (Hopkins *et al.*, 2009; Manget *et al.*, 2009). In turn, understanding how to profit from environmental innovative investments bears great importance for firms.

Second, on a more general basis, in the managerial literature there is a growing interest in assessing the impact that specific strategies and practices might have on firms' performance. From marketing point of view, several studies have addressed this issue (Cano, 2004; Ellis, 2006; Kirca *et al.*, 2005; Shoham *et al.*, 2005). Similarly, other authors have analyzed the relationship between innovative investments and firms' performance (Laforet, 2009; Sood *et al.*, 2009; Sorescu *et al.*, 2008). However, very few studies (Srinivasan *et al.*, 2009) have tried to integrate the two aspects and explore how the exploitation of marketing *and* innovative strategies and actions affect firms' performance. This paper aims at offering a contribution to this issue.

The paper is organized as follows. In the following section we review the previous literature and formulate our main hypotheses. In Section 3 we describe the database used for the analysis and introduce the empirical methodology. In Section 4 we show the empirical analysis and present our main econometric results. In Section 5 we simulate the behavior of financial market's response to different levels of firms' green technological and marketing activity. Finally, Section 6 concludes.

2. Literature review and hypotheses

2.1 Corporate environmentalism, environmental marketing strategies, and firms' performance

The underlying assumption of corporate environmentalism is that firms should pay attention to the environmental issues and modify their strategies accordingly, in order to transform what can be perceived as a disadvantage or a threat to the firm's competitive position into an opportunity to build or sustain a competitive advantage. This transformation from an external threat to a market opportunity arises according to three alternative – though not necessarily substitutive – directions.

First, the growing interest of public opinion towards the environment and towards the risks of pollution associated to the industrial activity has meant that a new segment of consumers (usually referred to as *green consumers*) has emerged and has become attractive to firms. In turn, firms may decide to target such a segment by developing green (or greener) products, that is, products that can be recycled or reused, that generate less pollution in their production or use, that are made of recycled materials, that involve less packaging, and so forth. Green products are usually perceived as being higher quality with regards to conventional alternatives, thus green consumers are willing to pay for such products a price premium of up to 20% (Manget *et al.*, 2009). As a consequence, by developing green products, firms have the possibility to enter into new market segments and increase or sustain over time their market share (Roy, 1999).

Second, even without deciding to develop green products in order to target new market segments, firms can leverage their environmental orientation to differentiate their offering with respect to competitors' offerings. This differentiation arises because consumers perceive a different positioning for products and services that are proposed by environmentally-concerned firms (Bonifant *et al.*, 1995; Porter *et al.*, 1995; Shrivastava, 1995a). In turn, differentiation becomes a source of competitive advantage.

Similarly, and third, firms can build a competitive advantage by lowering their costs. Indeed, in re-thinking their production processes through the lenses of corporate environmentalism firms can pursue cost efficiency. Cost savings are due the use of cheaper recycled materials, or energy savings or process improvements as a consequence of manufacturing systems re-design (Shrivastava, 1995b; Simon, 1992; Smith, 1991).

A consequence of these three alternatives is that the competitive advantage resulting from an environmental orientation leads to superior performance. This relationship has been empirically assessed. For instance, Menguc and Ozanne (2005), by adopting Resource Based View approach, prove that a firm's natural environmental orientation" is positively and significantly related to profit after tax and market share, and negatively related to sales growth. Similarly, Orsato (2006) shows that specific types of competitive environmental strategies lead both to competitive advantage, and to economic returns on environmental investments.

Accordingly, we draw the following hypothesis:

H1: *Corporate environmentalism and environmental marketing strategies are positively related to the firm's financial performance.*

2.2 Environmental technologies and firms' performance

The existence of a positive relationship between the successful development of environmental technologies and the firm's performance has been discussed and revealed by several studies. Similarly to the discussion conducted in the previous section, the underlying hypothesis of all those studies is that investments in environmental technologies offer to firms the opportunity to build or reinforce their competitive advantage.

In turn, such a competitive advantage can be leveraged in the market and converted into higher financial performance.

For instance, Lefebvre et al. (2003) make use of survey data from a sample of almost 400 environmentally responsive SMEs operating in four industries to show how the development of environmental management systems and investments in environmental R&D have an impact on firms' innovativeness and competitiveness. At the same conclusion arrives a subsequent study (Chen *et al.*, 2006) conducted on a sample of 232 firms in the information and electronics industries in Taiwan. The authors consider two different types of environmental technologies – Green Product Innovations and Green Process Innovations – and observe that the performance of both types positively affects the firm's competitive advantage. On the basis of this result, they conclude that firms that are environmentally oriented are able to build a Green Intellectual Capital, which can be exploited to create a competitive advantage (Chen, 2008b).

It is worth noticing, however, that not all types of environmental technologies can lead to superior performance. It strictly depends on whether the technological development builds on the existing production process (and "simply" aims at reducing the environmental impact of it), or rather represents a radical re-design of the process aimed at impeding – not reducing – the generation of pollution since the beginning. Because technologies belonging to the former category do not modify the manufacturing process, they cannot induce an efficiency increase. Rather, such technologies represent an additional cost that reduces the production efficiency. By contrast, the development of technologies belonging to the latter category gives to firms the possibility to re-formulate their manufacturing process in a way that enhances its efficiency with respect to previous solutions. Even though the process re-design implies higher development costs and a longer time need, the firm might benefit of a cost advantage in the long run.

According to this framework, Klassen and Whybark (1999) distinguish among three types of environmental technologies: a) "pollution prevention" technologies, which are related to product and process adaptation; b) "management systems", which are related to the way manufacturing processes are managed, and; c) "pollution control" technologies, which represent end-of-pipe or remediation solutions. They observe that while the first type of technologies determines an increase of manufacturing performance, the latter type worsens manufacturing performance (the second type does not play any effect).

Therefore, the time that a firm has available to develop an environmental technology plays a key role in determining the subsequent success for the company. Often, in the short run, an environmental orientation does not lead to any profitability increase (Gonzalez-Benito *et al.*, 2005a). Indeed, if environmental innovations are the results of (market and regulatory) pressures to be quickly satisfied, the firm might prefer to pursue more superficial transformations based on end-of-pipe technologies. By contrast, if a firm's response is expected in a longer time, deeper transformations might be promoted. Such transformations will affect the way in which products are manufactured and conceived, thus offering to the firm a source of efficiency increase and thus of competitive advantage (Gonzalez-Benito *et al.*, 2005b).

On the basis of these arguments, we draw the following hypothesis:

H2: *The development of environmental technologies is positively related to the firm's financial performance.*

2.3 Environmental marketing strategies, environmental technologies and firms' performance

The question raised by the latter discussion points to the existence of a relationship between the firm's motivation to implement an environmental management practice, the type of technology that most likely will be developed, and the resulting competitive advantage. Specifically, if the main motivation behind environmental activity is the attempt to quickly differentiate the image and products of the firm, then more superficial and external observable transformations (i.e., end-of-pipe technologies) might be preferred (Gonzalez-Benito *et al.*, 2005b). The paradoxical implication of such a choice is that, not only performance increase will hardly occur, but also the image of the company might eventually be negatively affected, and the firm accused of "greenwashing" (Laufer, 2003).

The main issue is that, if a firm is environmentally oriented and such orientation induces the firm to develop environmental technologies and to implement marketing practices, then such investments have to be conducted in parallel, with the one reinforcing the effect of the other. In this sense, Gonzales-Benito et al. (2005a), using a sample of Spanish manufacturing firms, show the existence of a positive and significant effect from the technological to the marketing dimension, by which certain operational performance objectives positively affect the firm's marketing performance (i.e., company reputation, customers' satisfaction and success of new product launches).

Overall, it seems that the adoption of an environmental orientation can lead to superior performance only if the company is able to build a "green core competence" (Chen, 2008a), which pervades the entire organization and which drives both the development of environmental technologies and the firm's marketing activities. As shown in figure 1, a firm's green core competence affects its ability to develop green product and process innovations and, simultaneously, its ability to build a green corporate image – that is, corporate reputation and corporate credibility (Chen, 2008a; Keller *et al.*, 1992; Martínez *et al.*, 2005). Furthermore, the successful development of environmental innovations enhances the capability of the firm to build its green image.

FIGURE 1 ABOUT HERE

In turn, the positive interaction between environmental innovative effort and the pursue of environmental marketing strategies (aimed at promoting a corporate green image) should strengthen the positive effect that the two dimensions separately play on firm's performance, according to what stated in hypotheses 1 and 2. That is, the development of environmental technologies that is supported by a related marketing strategy maximizes the exploitation of the firm's environmental orientation.

Based on these considerations, we formulate our third hypothesis:

H3: *In order to maximize the competitive advantage arising from an environmental orientation, environmental technologies (re-design of products and manufacturing processes) should be developed in parallel with environmental marketing strategies (green communication effort and new green product introduction).*

3. Empirical analysis

3.1 Sample

In order to test our hypotheses, we considered a sample composed by US-based, large firms operating in the chemical industry, over the period 1999-2008 (ten years in total).[1] From all the firms included in the S&P 500 index for 2009, we extracted the list of those firms belonging to the SIC code 28xx (Chemicals and Allied Products).[2] Thus, thirty-nine firms

[1] We decided to focus our attention on this time period because of the availability of data. Nevertheless, that decade has been very relevant as far as the environmental issue is concerned. Thus, we believe that our data limitation does not affect the significance of the analysis.

[2] The S&P 500 index, owned and maintained by Standard & Poor's (a division of McGraw-Hill), is a free-float capitalization-weighted index that includes the stocks of large public companies that trade on either the NYSE Euronext or the NASDAQ OMX stock exchange markets.

were included in the sample. As shown in table 1, most of our sample firms (23 out of 39) belong to Pharmaceuticals (SIC 283x), while the remaining companies are spread over the remaining subsectors of the chemical industry.

TABLE 1 ABOUT HERE

We decided to focus our attention on the chemical industry because, more than others, chemical companies have often been accused of being highly responsible for pollution. As a matter of fact, the processes of production, distribution and use of chemical compounds can be very dangerous, and some relevant accidents (such as Seveso, Italy and Bhopal, India) have contributed to generating a diffuse suspis ion against chemicals. As a matter of facts, the US Environmental Protection Agency (EPA), on the basis of the Toxic Chemical Release Inventory, has consistently rated the chemical industry as one of the biggest polluters (Hoffman, 1999; Ochsner, 1997). Furthermore, other studies (among others, see Banerjee *et al.*, 2003) include the chemical industry among the high environmental impact sectors. Accordingly, we expect many chemical firms to be highly committed to solving environmental problems, and this makes the chemical industry a natural test-bed for our hypotheses.

Starting from that list of firms, we referred to different data sources to draw information relevant for our analysis. Specifically, we collected financial information from the Compustat database,[3] patent data from the on-line patent search engine of the US Patent and Trademark Office,[4] and information on new products introduction from the Infotrac's Promt database.[5] On the basis of this data collection process we were able to build the variables used in the econometric estimation.

3.2 Variables

In order to assess firms' financial performance, we considered the Tobin's q indicator, which is largely used in financial studies. Formally, Tobin's q represents the ratio between the market value of a firm and the replacement cost of its assets, and it is intended to reflect the evaluation that financial markets have of the firm's value. For our purposes, it has to be considered as a financial performance indicator that wraps together several aspects of the firm's activity, from profitability, to efficiency and so forth. In order to compute Tobin's q values for our sample firms (for the years considered in the analysis), we made use of data from Compustat. Given that there are alternative computational procedures that can be used to obtain q values, we opted for an approximation suggested by Chung and Pruitt (1994), who compute q as follows:

$$\text{Tobin's } q \text{ (Approximate)} = (\text{MVE} + \text{PS} + \text{DEBT}) / \text{TA}$$

where:

- **MVE** = Share Price * Number of Common Stock Shares Outstanding
- **PS** = Liquidating Value of the firm's Outstanding Preferred Stock
- **DEBT** = Short-term Liabilities (net of Short-term Assets) + Long-term Debt (book value)
- **TA** = Total Assets (book value)

[3] The COMPUSTAT database from Standard & Poor's (McGraw-Hill) is one of the most extensive and largely used databases of business financial data available. It provides annual and quarterly financial data (proceeding from companies' income statements and balance sheets) on over 10,000 firms dating back to the 1950s.

[4] http://www.uspto.gov/patents/process/search/index.jsp.

[5] The Infotrac's Promt database collects press articles from a large set of trade journals, magazines, and other specialized publications, and then classifies those articles according to several categories of events, classified by SIC codes, and reference companies.

As for our measure of environmental technologies, we performed a patent search over all patents granted to our sample firms in the US Patent and Trademark Office. By following a procedure already adopted in previous studies (Arduini *et al.*, 2004; Nameroff *et al.*, 2004), we performed a key-word patent search in order to identify environmentally-related patents among each firm's patent portfolio. Specifically, we referred to specialized, technical publications to obtain a list of potential key-words that were associated to environmental technologies and that could be retrieved in patent documentation. Then, we submitted such a list to two external advisors having expertise in chemical technologies,[6] in order to validate each individual key-word. In turn, validated key-words were searched in patents' claims. Finally, we drew a sample of obtained patents that then we read and analyzed one by one to check for any error or misinterpretation. Because we used a very conservative method to select the appropriate key-words, the resulting error rate is lower than 5%. By following this procedure, we were able to compute, for each firm, the number of environmentally-related (green) patents for any year of the analyzed time period. Table 1 reports a summary of this information.

It has to be underlined that the procedure that we used to collect patent data does not allow us to distinguish between product and process technologies. In this respect, our approach is in line with Chen et al. (2006, p. 333), who define green innovation "as hardware or software innovation that is related to green products or processes, including the innovation in technologies that are involved in energy-saving, pollution-prevention, waste recycling, green product designs, or corporate environmental management". This means that our sample firms might differ substantially in the typology of environmental innovations they develop. While some of them may mainly focus on the development of green products, others may pay higher attention in making their manufacturing processes more environmentally safe. It appears evident that those two types of innovative investments have different effect on the corporate image perceived by consumers or agents of the financial markets, but unfortunately we cannot distinguish between them. Furthermore, it is worth noting that among different categories of environmental technologies, end-of-pipe and recycling technologies are more likely to be protected with patents, while clean technologies (i.e., those that imply a radical process and product re-design) are less likely to receive patent protection (Arduini *et al.*, 2004). In turn, it might be that our measure of environmental technologies underestimates the real effort that our sample companies devote to the issue.

As far as our measure of environmental marketing strategies is concerned, we built an indicator – Green Marketing Announcements –, that was obtained from the InfoTrack's Promt database. By following a procedure adopted in previous studies (Fosfuri *et al.*, 2009; Fosfuri *et al.*, 2008; Giarratana, 2008; Giarratana *et al.*, 2007),[7] we searched the database to identify those press articles that were related to each one of our sample firms and that were belonging to the following events: "Advertising", "Marketing Procedures", "Product Development", "Product Information", and "Product Introduction". Within each one of the event-categories, we then performed a key-word search in the text of the article to select those announcements that were related to green products and/or green marketing.

We believe that such a measure is able to capture different aspects of firms' environmental marketing strategies. In general terms, a firm pursuing an environmental marketing strategy develops a green marketing-mix composed by the following elements (Rivera-Camino, 2007):

1. politics of green product design;
2. distribution with green criteria;
3. pricing of green products; and

[6] The first advisor is a chemical processing engineer working for a worldly major aluminum producer, while the second advisor is a university professor of chemical engineering and specialized in environmental chemical technologies.

[7] The InfoTrack's Promt database is the revised version of an old database (Predicast), which has been used extensively in the literature (see, for instance, Pennings and Harianto, 1992).

4. green publicity and green sponsoring.

Thus, by using our Green Marketing Announcements indicator, we aim at capturing firms' actions related to the first and the fourth elements of a green marketing-mix. Obviously, also the remaining two elements are worth of attention, because they directly affect the consumers' perception of a firm's environmental activity and, in turn, its green image. Again, as for the case of environmental technologies, it could be that our measure underestimates the real effort that firms do in environmental marketing strategies.

Finally, we also built a set of control variables: firm's size (number of employees); R&D intensity (R&D expenditure over sales); firm's total assets; firm's intangible assets; and, firm's net income. All these measures were computed by using data drawn from Compustat. Tables 2 and 3 report summary statistics of the variables we used.

TABLE 2 ABOUT HERE

TABLE 3 ABOUT HERE

3.3 Econometric model

In order to derive our econometric model, we took into account both theoretical and practical considerations. First, we referred to previous studies that attempted to estimate the impact of firms' (marketing and/or innovative) strategies on performance. Specifically, we mainly considered a study conducted by Krasnikov et al. (2009). By using data on trademarks as a measure of firms' branding effort, they empirically assessed the impact of branding on various measures of firms' financial outcomes. Second, we considered the specific characteristics of our data. Given that we have to deal with a balanced panel dataset, we both considered the application of fixed effect and random effect models, which allow to control for omitted variables that differ between cases but are constant over time, and for omitted variables that may be fixed between cases but vary over time, respectively.

Eventually, our econometric model resulted as follows:

$$(1) \qquad \boldsymbol{P}_{it} = \beta_{0i} + \beta_{1i}\, \boldsymbol{GrPatStockSh}_{it} + \beta_{2i}\, \boldsymbol{GrMktgSh}_{it} + \beta_{3i}\, \boldsymbol{NI}_{it} + \varepsilon_{it}$$

where:

- **i** = firm;
- **t** = year;
- **P** = Performance indicator (Tobin's q);
- **GrPatStockSh** = share of green patents stock (i.e., stock of green patents over total stock of patents);
- **GrMktgSh** = share of green marketing announcements (i.e., green marketing announcements over total marketing announcements);
- **NI** = Net income

In order to take into account of possible heterogeneity related to firm level characteristics, we modeled the variation in intercept and independent variables' coefficients as follows:

$$(2) \qquad \begin{aligned} \beta_{\mathbf{0}i} &= \gamma_{\mathbf{0}i} + \gamma_{01i} Z_i + \varphi_{\mathbf{0}i} \\ \beta_{\mathbf{1}i} &= \gamma_{\mathbf{1}i} + \varphi_{\mathbf{1}i} \\ \beta_{\mathbf{2}i} &= \gamma_{\mathbf{2}i} + \varphi_{\mathbf{2}i} \\ \beta_{\mathbf{3}i} &= \gamma_{\mathbf{3}i} + \varphi_{\mathbf{3}i} \\ \beta_{\mathbf{4}i} &= \gamma_{\mathbf{4}i} + \varphi_{\mathbf{4}i} \end{aligned}$$

where Z is a vector of firm-level controls (firm's size, R&D intensity, total assets and intangible assets) that might affect firms' performance apart from the effect played by our key explanatory variables.

Finally, in order to assess whether those firms that pose the same attention in the development of environmental technologies and in the exploitation of green marketing strategies benefit of superior financial results, as suggested by Hypothesis 3, we included two interactive variables in our model:

$$(3) \qquad \boldsymbol{P}_{it} = \beta_{0i} + \beta_{1i}\, \boldsymbol{GrPatStockSh}_{it} + \beta_{2i}\, \boldsymbol{GrMktgSh}_{it} + \beta_{3i}\, \boldsymbol{NI}_{it} + \\ + \beta_{4i}\, \boldsymbol{GrPatStockSh}_{it} \cdot \boldsymbol{GrMktgSh}_{it} + \varepsilon_{it}$$

Thus, the two interactive terms are aimed at capturing the existence of any reinforcing effect of environmental technology development over the two dimensions of environmental marketing strategies, as suggested by Chen (2008a).

4. Results

As suggested above, we empirically estimated our model by using both fixed effects and random effects panel models. Then, we run a Hausmann test to check which model is more efficient and more likely to provide consistent estimations. Based on the results of the test (available on request), we decided to exclude the need to use a random effects model. In turn, we only present results related to the fixed effects model. Table 4 provides findings from the analysis.

TABLE 4 ABOUT HERE

As shown in the table, we estimated four different model specifications, by gradually introducing our key explanatory variables, from the share of the stock of environmental patents, to the share of environmental marketing actions, to the interactive effect of those dimensions. The first key result emerging from our estimations is that **GrPatStockSh** is positively associated (and statistically significant) to our performance indicator (Tobin's *q*). This result holds for all the specifications. Thus we can conclude that, according to our estimation's results, Hypothesis 1 is confirmed.

Also Hypothesis 2 is supported by our data. Indeed, **GrMkgtSh** is positively associated to the value of Tobin's q in all the specifications of the model. However, the marginal effect of this variable on firms' performance seems smaller than that of green patents (i.e., the value of the estimation coefficient related to green patents is greater than the estimation coefficient related to green marketing). Thus, similar increases in the share of green patents and of green marketing announcements produce dissimilar effects on firms' value, with the former much larger than the latter.

Besides this, however, the main result emerging from our analysis is that when environmental innovations are promoted jointly to environmental marketing actions, the financial market reduces its evaluation of firms' value. Indeed, as shown in specification IV, the coefficient related to the interactive term included in the econometric model has a negative sign, meaning that the interaction between green patents and green marketing announcements is negatively associated to Tobin's *q*. Therefore, Hypothesis 3 is not supported by our data.

Several explanations might account for this result. On the one hand, it could simply be the effect of some econometric concerns related to the relationship existing between the green patent variable and the green marketing variable. Given that in the green marketing indicator we also included announcements related to product development, the negative sign of our estimation coefficient might reflect the direct association between technological development and new product introduction. On the other hand, such a negative coefficient related to the interactive term might indicate that the financial market misinterprets the signals provided by the technological and the marketing functions of firms' activities. Given that Tobin's *q* is affected by the evaluation that financial markets do of firms' values, a misinterpretation of firms' activities might result in their negative financial evaluation. On this line of reasoning, it could also be argued that technological information takes time to shift from the company to the financial market. As we included patents in the dataset according to the filing data, it might be that the effect of a new patent filing is reflected in the financial market's evaluation only after some periods of time, and this time inconsistency with respect to the moment in which product announcements occur might explain the misinterpretation of financial markets. We will better explore all these issues in future research steps.

5. Simulation analysis

In order to explore the causes that bring to the rejection of Hypothesis 3, and thus to better analyze the interaction between green patents and green marketing announcements, we performed a simulation exercise. We considered an "average firm" characterized by all control variables (net income, number of employees, R&D intensity and intangible assets) set at their respective mean values. Then, we let **GrPatStockSh** assume values from 0 to 10% (that represents the maximum value in our data) and **GrMkgtSh** assume values from 0 to 100%. Finally, by using the estimated coefficients, we computed firms' Tobin's q for each value of **GrPatStockSh** and **GrMkgtSh**. Results of this simulation exercise are reported in figure 2.

FIGURE 2 ABOUT HERE

The analysis of figure 2 clearly confirms our previous discussion. First, an increase in each one of the two dimensions (either green patents or green marketing announcements), by keeping the other constant, produces an increase in Tobin's q. Second, the effect of green patents on Tobin's q is greater than the effect produced by green announcements. Finally, when both variables are set at their respective maximum values, the level of Tobin's q is smaller than the level reached when **GrPatStockSh** is set to 10% and **GrMkgtSh** equals 0.

However, this behavior changes according to the typology of firms. If we distinguish those firms that operate in the B2C market from those that operate in the B2B market, we obtain radically different results, as figures 3 and 4 show. In the case of B2B firms, environmental marketing actions have a very limited (if not null) effect on firms' market value, which is only influenced by green technological developments. By contrast, when firms operate in the final, customer market, the effect of environmental marketing actions is much stronger. Tobin's q increases when firms either invest in the development of environmental technologies or communicate to the public their environmental concern, but decreases when both actions are promoted simultaneously.

FIGURES 3 AND 4 ABOUT HERE

In this latter case it seems that the financial market discounts the effect of one action over the other. It is worth noting that a large fraction of environmental marketing announcements concern the market introduction of green products, which (we guess) result from an earlier development of some green technologies. Thus, if firms' value has been positively affected by earlier patent-protected technological improvements, then when the applications of those improvements are converted into innovative products introduced in the market, their effect on firms' performance has already been anticipated by the financial market, and any communication effort by firms does not change the overall firms' evaluation. Rather, it could be interpreted as an attempt to overemphasize firms' environmental concern, above their actual level – which is expressed by the amount of green technologies.

Clear managerial implications arise from this result. Firms that operate in the customer market should pay great attention to the their communication strategies and avoid to provide redundant information about their environmental actions. Specifically, if their environmental concern arises from the development of some sort of green technologies, this information alone produces positive effects on the firms' market evaluation. By contrast, green communication matters when firms' environmental concern derives either from non-technological innovations (e.g., organizational modifications, change in internal procedures), or from outsourced green technologies that are not reflected in internal technological improvements.

6. Discussion and conclusions

During the last years, the interest devoted to the topic of corporate social responsibility and, specifically, to the impact that firms' actions have on the natural environmental has constantly grown. Both academic researchers and firms' practitioners have increasingly paid attention to which policies and strategies firms should adopt in order to be perceived as socially responsible or as environmentally concerned. Even more importantly, a great deal of attention has been directed to the assessment of the consequences of such policies and strategies on firms' results. This paper contributes to this line of research by providing novel empirical evidence of how the evaluation that financial markets make of firms' value is affected by their environmentally-related actions.

Specifically, we took into consideration two dimensions of firms' activities. The first one – green technology development – is supposed to be less observable from external financial markets, while the second one – green marketing strategies – is supposed to account for the effort that firms do in communicating with the external environment their involvement in environmentally responsible actions. Nevertheless, the results of our empirical estimations seem to show that financial performance is affected more by the technological dimension than the marketing dimension. Thus, a first, clear managerial implication arising from our study is that investments in environmental technologies are positively rewarded by financial markets, and this could be interpreted as a confirmation that it is possible to gain some sort of advantage by investing in environmental innovations.

Obviously, also pursuing a green marketing strategy generates positive results to the firm. However, when green marketing actions are associated to the development of environmental technologies, then the effect on firms' performance might be lower than expectations, and strictly depends on the typology of firm (B2C vs. B2B). This is a second relevant result of our study, whose direct managerial implication entails that firms should spend more attention in modulating their "green communication" effort, depending on the results of their green technological activity.

Our study also suffers of some limitations that we aim at facing in future research steps. First, we need to assess the relevance of any endogeneity issues, which refer to the possibility that both sides of our econometric model might be simultaneously determined. We will firstly check the relevance of such problems, and then adopt appropriate changes to the econometric methodology.

The second limitation has to do with the use of patent statistics. As expressed above, patents may only capture a fraction of the effort that firms put in developing environmental technologies, so that it would be useful to complement patent statistics with other measures of firms' technological activity. Furthermore, as suggested by the innovation literature, patents differ in terms of quality characteristics, and we plan to use citation counts to include quality issues in our analyses. Finally, because we have considered granted patents at the date of filing, it is likely that the very last years of our dataset suffer of an underestimation of patent data, due to the existing time lag between filing and granting.

Finally, even though Tobin's q as a measure of financial performance is largely used (and accepted) in the managerial and finance literature, its adoption (and interpretation) in the practice is less widespread. Thus, we aim at considering alternative measures of financial performance (such as cash flow volatility, return on assets and stock returns), and to assess whether the obtained results hold also with these alternative measures. If so, they would reinforce our main conclusions.

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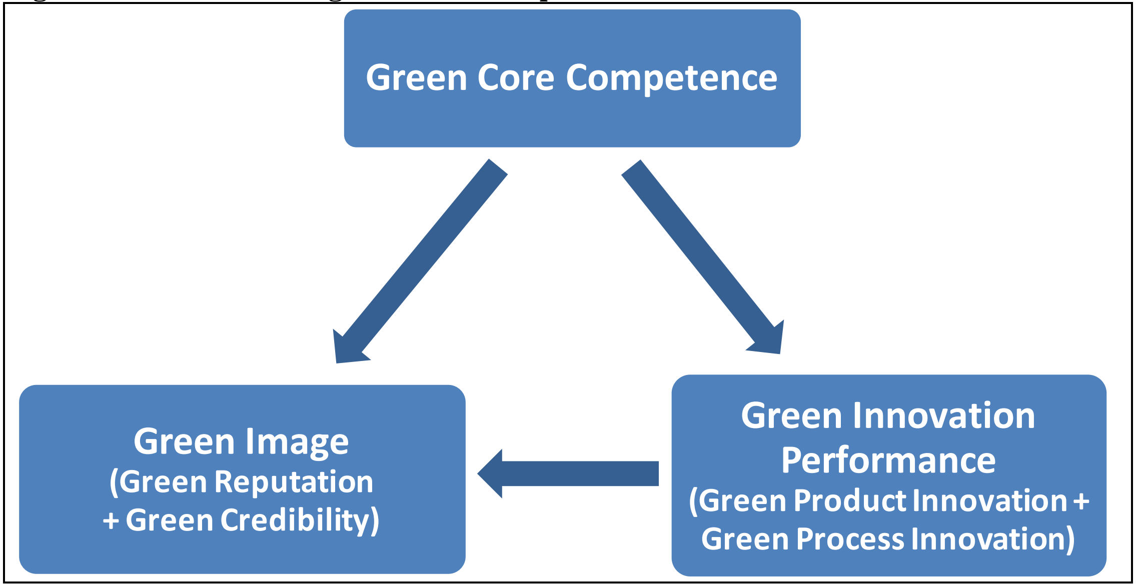
Figure 1 – The effect of green core competence



Source: adapted from Chen (2008a)

Figure 2 – Effect of green patents and green marketing announcements on Tobin's q. Simulation exercise

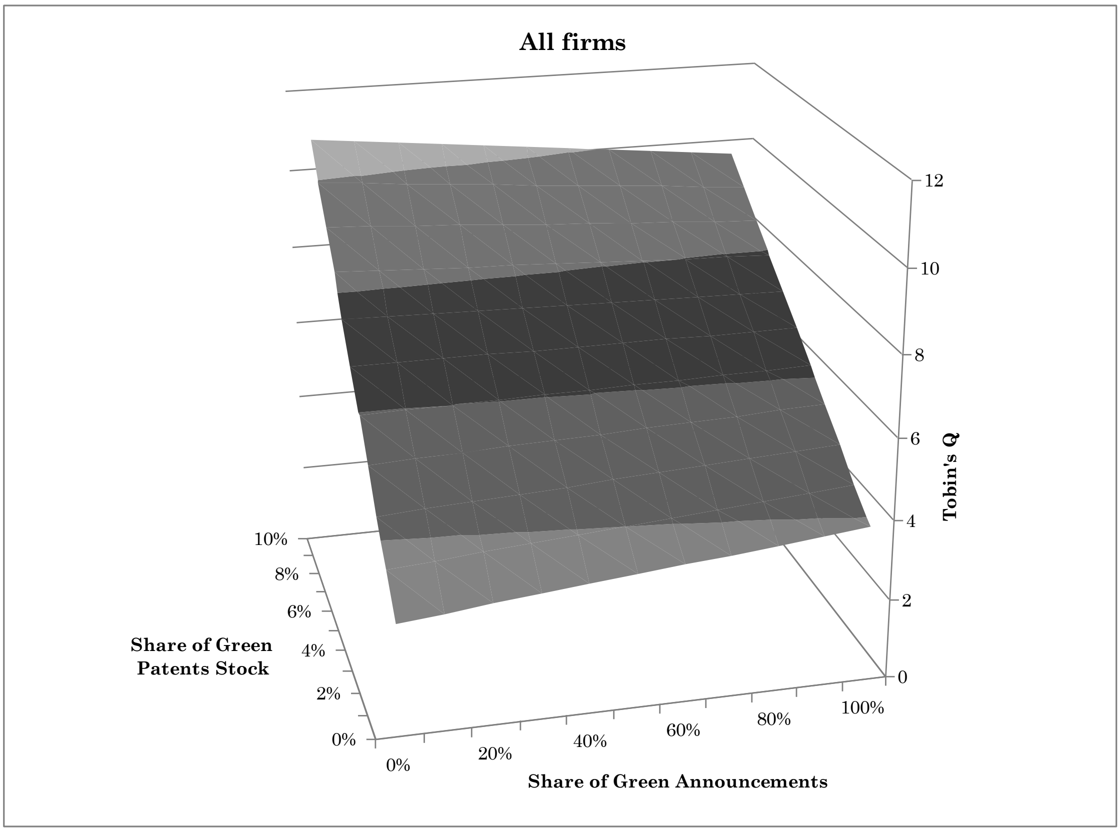


Figure 3 – Effect of green patents and green marketing announcements on Tobin's q for B2C firms

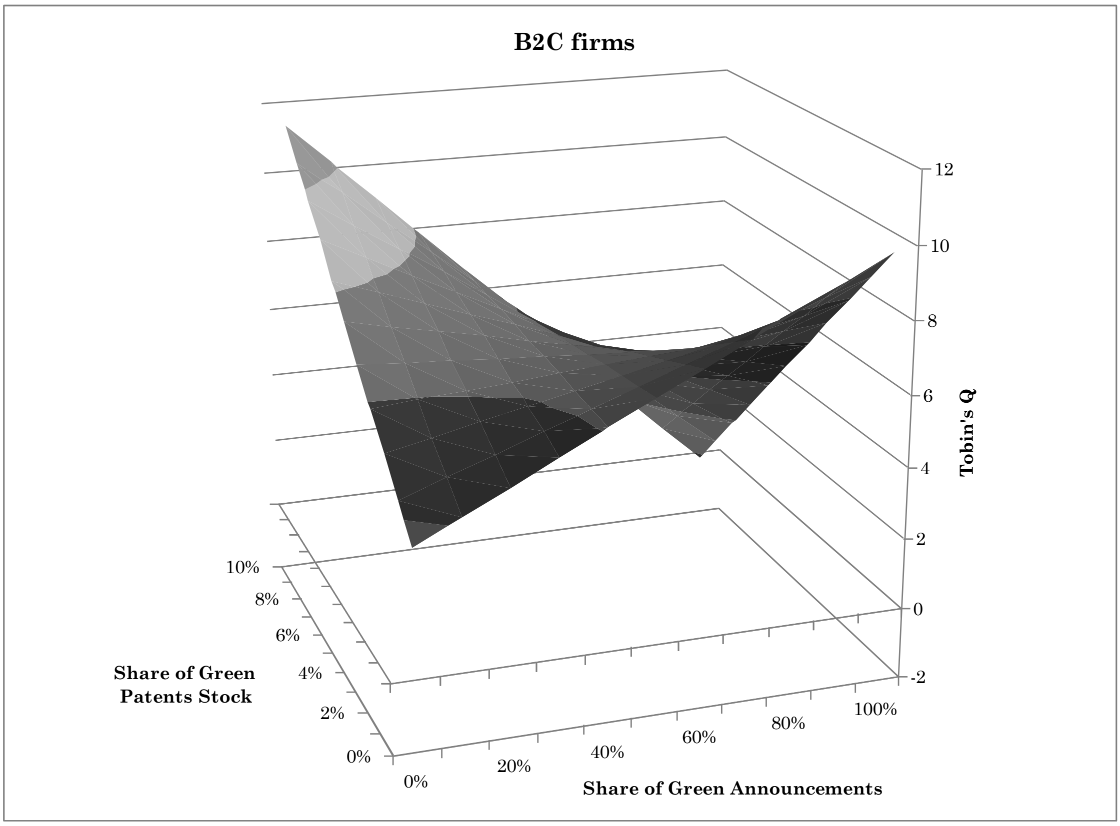


Figure 4 - Effect of green patents and green marketing announcements on Tobin's q for B2C firms

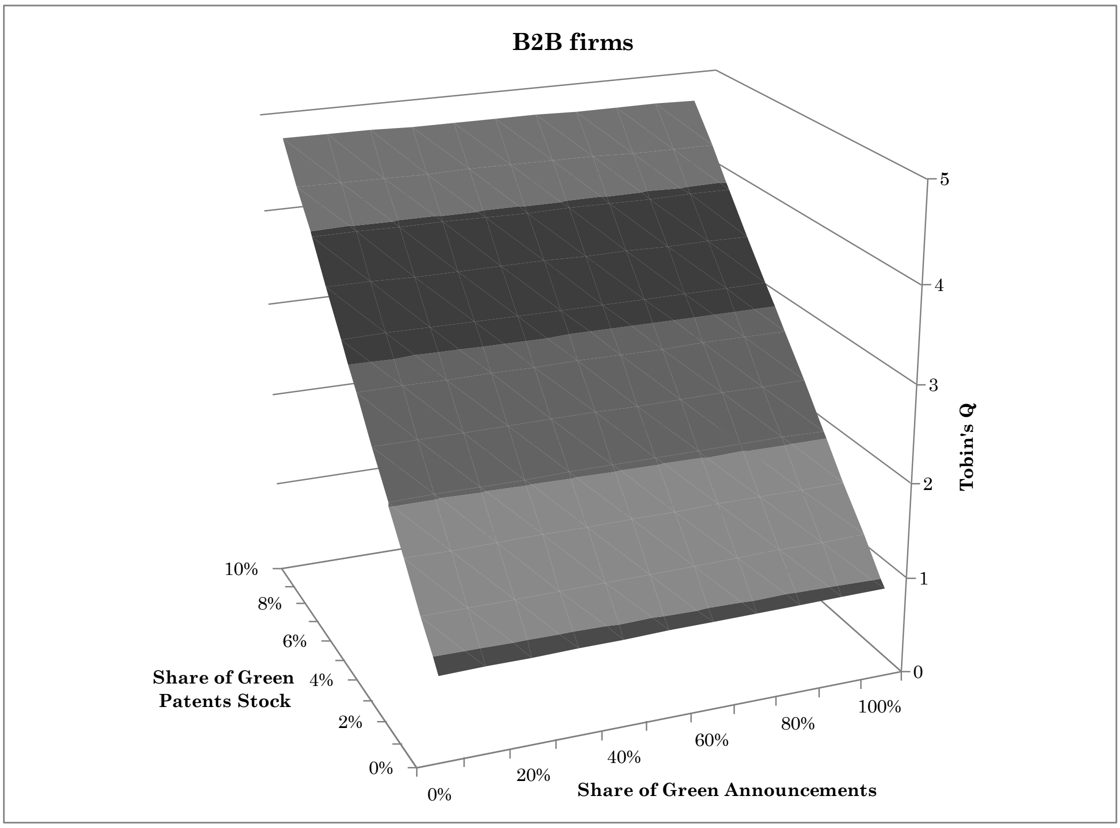


Table 1 – Main companies' characteristics

#	Company Name	SIC
1	ABBOTT LABORATORIES	2834
2	AIR PRODUCTS & CHEMICALS INC	2810
3	ALLERGAN INC	2834
4	AMGEN INC	2836
5	AVON PRODUCTS	2844
6	BAXTER INTERNATIONAL INC	2836
7	BIOGEN IDEC INC	2836
8	BRISTOL-MYERS SQUIBB CO	2834
9	CELGENE CORP	2834
10	CEPHALON INC	2834
11	CF INDUSTRIES HOLDINGS INC	2870
12	CLOROX CO/DE	2842
13	COLGATE-PALMOLIVE CO	2844
14	DOW CHEMICAL	2821
15	DU PONT (E I) DE NEMOURS	2820
16	EASTMAN CHEMICAL CO	2821
17	ECOLAB INC	2842
18	FOREST LABORATORIES -CL A	2834
19	GENZYME CORP	2836
20	GILEAD SCIENCES INC	2836
21	HOSPIRA INC	2834
22	INTL FLAVORS & FRAGRANCES	2860
23	JOHNSON & JOHNSON	2834
24	KING PHARMACEUTICALS INC	2834
25	LAUDER (ESTEE) COS INC -CL A	2844
26	LIFE TECHNOLOGIES CORP	2836
27	LILLY (ELI) & CO	2834
28	MERCK & CO	2834
29	MYLAN INC	2834
30	PFIZER INC	2834
31	PPG INDUSTRIES INC	2851
32	PRAXAIR INC	2810
33	PROCTER & GAMBLE CO	2840
34	SCHERING-PLOUGH	2834
35	SHERWIN-WILLIAMS CO	2851
36	SIGMA-ALDRICH CORP	2836
37	SMITH INTERNATIONAL INC	2890
38	WATSON PHARMACEUTICALS INC	2834
39	WYETH	2834

Table 2 – Descriptive statistics

Variable		Mean	Std. Dev.	Min	Max	Observations
TobinsQ	overall	3.570075	2.954654	1.05184	23.81422	N = 416
	between		2.509156	1.383627	16.11662	n = 39
	within		1.569584	-4.214013	11.51916	T-bar = 10.6667
ROA	overall	7.084445	16.3886	-268.67	28.673	N = 420
	between		8.420964	-35.16764	15.97545	n = 39
	within		14.06729	-226.4179	48.52208	T-bar = 10.7692
CashFlow	overall	1929.301	2956.387	-1384.752	16425	N = 420
	between		2649.627	-93.62063	9860.091	n = 39
	within		1337.66	-5515.79	8758.847	T-bar = 10.7692
GrPatSh	overall	0.0125834	0.064765	0	1	N = 429
	between		0.0274366	0	0.1296707	n = 39
	within		0.0588161	-0.1170873	0.9216743	T = 11
GrPatStockSh	overall	0.0141327	0.023087	0	0.1111111	N = 429
	between		0.0232034	0	0.1111111	n = 39
	within		0.0026813	0.0031076	0.0325193	T = 11
GrPASh	overall	0.0612142	0.1646437	0	1	N = 390
	between		0.0818538	0	0.3142857	n = 39
	within		0.1433964	-0.2530716	0.935189	T = 10
GrMktgSh	overall	0.0544207	0.1769133	0	1	N = 390
	between		0.0787877	0	0.25	n = 39
	within		0.1588535	-0.1955793	0.9544207	T = 10
NI	overall	1429.392	2450.477	-2370.687	19337	N = 420
	between		2103.341	-115.7601	7828.273	n = 39
	within		1273.782	-3285.024	12938.12	T-bar = 10.7692
Employees	overall	29244.1	30549.51	112	138000	N = 418
	between		30121.49	847.6364	115454.5	n = 39
	within		6115.411	-13883.18	61716.82	T-bar = 10.7179
Intangible Assets	overall	3842.636	10167.39	0	94000	N = 418
	between		7109.497	0	34465.82	n = 39
	within		7280.019	-23801.18	63376.82	T-bar = 10.7179
R&D Intensity	overall	0.0769324	0.1124739	0	1.66	N = 414
	between		0.0737621	0.01	0.3909091	n = 38
	within		0.0854139	-0.2239767	1.346023	T-bar = 10.8947
Total Assets	overall	15033.22	21933.55	11.928	143992	N = 420
	between		18944.34	1364.533	77924.73	n = 39
	within		11244.9	-44589.51	90623.58	T-bar = 10.7692

Table 3 - Pairwise Correlations

	TobinsQ1	ROA	CashFlow	GrPatSh	GrPatStockSh	GrPASh	GrMktgSh	NI	Employees	Intangible Assets	R&D Intensity
TobinsQ	1.000										
ROA	-0.108	1.000									
CashFlow	0.069	0.185	1.000								
GrPatSh	-0.019	0.061	-0.036	1.000							
GrPatStockSh	-0.238	-0.012	-0.100	0.175	1.000						
GrPASh	-0.086	-0.031	-0.048	0.045	0.186	1.000					
GrMktgSh	-0.117	0.033	0.050	0.128	0.060	0.294	1.000				
NI	0.101	0.197	0.964	-0.038	-0.119	-0.059	0.029	1.000			
Employees	0.066	0.166	0.839	-0.059	-0.088	0.023	0.102	0.792	1.000		
Intangible Assets	-0.066	0.029	0.722	-0.048	-0.086	-0.030	0.041	0.676	0.626	1.000	
R&D Intensity	0.358	-0.778	-0.047	-0.057	-0.175	-0.161	-0.132	-0.030	-0.106	-0.035	1.000

Table 4 – Regression results (Fixed-effects (within) – Dep. Variable: Tobin's Q)

	I		II		III		IV	
GrPatStockSh	41.887	**			77.719	**	79.738	***
	(18.170)				(29.803)		(30.368)	
GrMktgSh			0.565	***	0.462	**	1.100	***
			(0.191)		(0.187)		(0.405)	
GrPatStockSh * GrMktgSh							-22.039	**
							(8.633)	
Net Income	2.4E-04	*	2.4E-04	*	2.4E-04	*	2.4E-04	*
	(1.3E-4)		(1.3E-4)		(1.3E-4)		(1.3E-4)	
Employees	-3.2E-05	*	-2.2E-05		-1.9E-05		-2.0E-05	
	(1.7E-5)		(2.0E-5)		(2.0E-5)		(2.0E-5)	
R&D Intensity	5.175	***	5.908	**	5.895	**	5.863	**
	(0.818)		(2.975)		(2.949)		(2.939)	
Intangible Assets	-6.5E-05	***	-6.8E-05	***	-6.8E-05	***	-6.8E-05	***
	(1.9E-5)		(2.0E-5)		(1.9E-5)		(1.9E-5)	
Constant	3.566	***	3.747	***	2.832	***	2.821	***
	(0.517)		(0.630)		(0.721)		(0.724)	
	N. obs = 405		N. obs = 335		N. obs = 335		N. obs = 335	
	F(5,363) = 13.89		F(5,293) = 6.29		F(6,292) = 5.90		F(7,291) = 4.96	

*p<0.10, **p<0.05, ***p<0.01. Robust Standard Errors in parentheses