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SUSTAINABILITY AND MARKET CONDITIONS: THE RESOURCE EFFICIENCY PARADOX

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ABSTRACT

In this paper we analyze the factors that drive the adoption of resource efficiency practices in constrained economic times. We uncover the 'paradox' of lower investments in resource efficiency practices in a downturn market and identify the characteristics of firms that seek the opportunity to invest more in such conditions. We argue that even though the attractiveness of resource efficiency practices should increase in downturn market conditions, such practices require complementary capabilities, strategies and organizational structure for their successful adoption. We test our framework using data from a French survey with responses from 5, 877 firms. Our results show that only 6% of the firms in our sample invest in resource efficiency practices in downturn markets, and that those firms are more likely to be vertically integrated, and to have a main focus on cost leadership strategies, have adopted environmental standards and conduct their research internally. We provide recommendations to encourage more widespread adoption of such models of frugal strategies.

Keywords: Business Strategy, Corporate Sustainability, Energy Efficiency, Resource Efficiency.

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1. INTRODUCTION

In the literature on business and the environment, important headway has been made in understanding the factors that drive firms to adopt environmental practices such as pollution prevention activities and international environmental management standards (Darnall et al., 2000; Delmas, 2001; Hart, 2005). However, less attention has been paid to the determinants of the adoption of resource efficiency practices. Such practices include reduction of raw material and energy use in the production of products or services.

Energy and resource efficiency practices have been recognized since the early 1970s as being profitable and desirable, and the recent economic downturn further enhances the appeal of the adoption of such frugal strategies. The promise of energy conservation investments and resource efficiency practices as key strategies in the effort to counteract the effects of climate change climate (IPCC, 2007) also adds to their desirability. However, evidence suggests that a significant proportion of energy and resource efficiency improvement potential remains untapped and that many energy and resource efficiency investments are not undertaken despite their apparent profitability (Expert Group on Energy Efficiency, 2007; DeCanio, 1993). In the current economic downturn, are firms more likely to invest in resource efficiency practices? Are changes in the economic context sufficient drivers of changes in firms' strategies regarding resource efficiency?

In this paper, we investigate the factors that drive energy and resource efficiency investments in different market conditions. In exploring this question both theoretically as well as empirically, the paper takes a first step towards studying the effect of market conditions on energy and resource efficiency investments, an issue that has received relatively little systematic analysis. We argue that firms' decisions to invest in energy and resource practices may differ according to the market conditions under which they operate, and that such

strategic choices may be contingent on the fit between the characteristics of the external market environment and the organization of the firm.

In order to test the impact of market conditions on investments in energy and resource efficiency practices, we use data from a large representative sample of 5,877 French firms with more than 20 employees; the data is drawn from three French cross-sectional surveys: the Organizational Changes and Computerization Survey (COI, 2006), the Community Innovation Survey (CIS8, 2006-2008) and the Annual Firm Survey (EAE, 2006). This allows us to introduce many factors that can be considered as significant incentives in a firm's decision to invest in energy and resource efficiency practices.

Our results show that, overall, energy and resource efficiency investments are lower under downturn market conditions. However, firms with complementary environmental strategies and internal R&D, firms that are vertically integrated, and firms that pursue general cost leadership strategies tend to invest significantly more in resource efficiency practices in these downturn market conditions.

In both its theoretical and empirical domains, this paper extends existing research. We still have limited understanding of how firms are developing strategies to cope with resource constraints while maintaining or even improving their economic sustainability. Building on previous literature analyzing the organizational factors that drive the adoption of environmental practices (Darnall and Edward, 2006; Delmas and Toffel, 2008), our research proposes a framework that highlights the links between existing organizational capabilities, market conditions and resource efficiency practices. We show that energy and resource efficiency practices are not adopted in isolation but operate in synergy with existing organizational capabilities and strategies. Our findings also have important policy implications, as they can enable policy-makers to better formulate and effectively apply resource efficiency policies.

LITERATURE REVIEW

Energy and resource efficiency practices aim at reducing the footprint of industrial activities (Kounetas and Tsekouras, 2008), and may be regarded as a constituting a significant share of all environmental innovations (Rennings and Rammer, 2009). *Energy efficiency* practices include all changes that result in decreasing the amount of energy used to produce one unit of economic output or services (e.g., Patterson, 1996). Resource efficiency result in reducing, or the amount or quantity of natural resources required to produce a given amount of product, with recycling of post-consumption waste material back into production contributing to material efficiency. Energy and resource efficiency practices include the adoption of products and practices that require a lower amount of raw materials or energy, as well as the adoption of products and practices that reduce the amount of material and energy needed during their use or to modify production or distribution methods (Rennings and Rammer, 2009). Efficient energy and resource practices not only reduce the negative environmental impact of a firm's activities, but also may often be translated into lower procurement and waste management costs, and into more general cost savings (Schmidt-Bleek, 1998; von Weizäcker et al., 1997; Hinterberger et al., 1997; Schleich, 2009).

Research indicates that, in spite of what would seem to be significant opportunities for profitability, many energy efficiency investments are not made; and a notable amount of energy efficiency improvement potential remains unrealized. (Expert Group on Energy Efficiency, 2007; DeCanio, 1993). Many explanations have been provided in the literature for this phenomenon, ranging from economic factors and complexity of regulation (Mueller, 2006) to organizational barriers such as misplaced incentives, risk aversion and shortsightedness of management (Blumstein et al., 1980; DeCanio, 1993). For example, scholars have argued that underinvestment in energy firms is explained by the so-called “split incentive” problem, involving “transactions or exchanges where the economic benefits of

energy conservation do not accrue to the person who is trying to conserve" (Golove and Eto, 1996). Another cause for underinvestment may be the alleged shortsightedness of management (DeCanio, 1993; Jaffe and Stavins, 1994; Thollander, 2008). This myopia would explain why energy-efficient investments require shorter payback periods or very high internal hurdle rates as compared to other investments (DeCanio, 1993; Ross, 1986; Sorrell et al., 2004). This literature also suggests that energy conservation may not attract top management interest and may therefore be given lower priority than other investments with similar payback (Sassone and Martucci, 1984). Although the literature focuses on cognitive or psychological factors, it has paid less attention to the question of how market conditions can influence the attractiveness of efficiency practices, as well as to the question of how such conditions interact with organizational factors.

Similarly, the business and the environment research efforts to date have been limited in their analyses of the roles played by market and economic conditions in the adoption of proactive environmental strategies. Most studies have focused on the influence of external stakeholders such as regulators, customers, or environmental non-governmental organizations, but have devoted less discussion to the general economic conditions surrounding the firm. These studies have investigated how the adoption of proactive environmental strategies is influenced by environmental legislation and regulations (Carraro et al., 1996; Delmas, 2002; Delmas and Montes-Sancho, 2010; Delmas, et al., 2007; Majumdar and Marcus, 2001; Rugman and Verbeke, 1998; Russo, 1992), customer demand (Christmann and Taylor, 2001; Delmas and Montiel, 2009), and the desire to improve or maintain relations with their communities (Florida and Davison, 2001; Henriques and Sadorsky, 1996). Other studies have shown that managerial perceptions of the importance of various stakeholder pressures were associated with a more proactive environmental stance (Delmas, 2001; Henriques and Sadorsky, 1999; Sharma and Henriques, 2005). The literature has also identified pressure from buyers as an

important mechanism through which quality management standards have diffused (Anderson et al., 1999); pressure from buyers has also played a significant role in motivating firms to adopt environmental practices (Delmas and Montiel, 2008). Several studies have found evidence that customer pressure has motivated firms to adopt environmental management practices, with one study noting that customer influence was second only to the influence of government pressure (Henriques and Sadorsky, 1996). A recent empirical analysis found customer pressure to be an important determinant of the likelihood of adopting the ISO 14001 standard (Delmas and Toffel, 2008). However, there is comparatively less empirical evidence on how general market conditions impact the adoption of such strategies.

Investigating the market conditions under which green practices have been adopted is important, because this information might have important implications for the costs and benefits of such practices. The literature has identified several opportunities for proactive environmental strategies to benefit shareholders directly (McWilliams and Siegel, 2001; Siegel, 2009). These include value creation strategies achieved through the development of greener products (Klassen and Whybark, 1999; Reinhardt, 1998), benefits resulting from non-market strategies to influence government regulation so that their rivals are at a disadvantage (Shrivastava, 1995), and cost savings achieved by preventing pollution (Ambec and Lanoie, 2008). Cost leadership strategies are expected to be more attractive in downturn economic conditions.

The lack of research, however, is problematic. Current economic conditions call for massive changes in the way business is undertaking its activities. For management researchers, it is important to find out the most favorable combination of organizational factors and market conditions to facilitate the adoption of frugal innovation.

2. HYPOTHESES

We first develop competing hypotheses on the role of downturn market conditions on the adoption resource efficiency practices, and then develop hypotheses on how organizational factors impact the adoption of such practices independently or in relation with downturn market conditions.

Market conditions

There are two competing hypotheses regarding the impact of market conditions on investments in resource efficiency practices. First, the literature indicates that investment in energy resource efficiency is associated with cost savings for firms in the light of expected high future energy prices, improved security of energy services, and other co-benefits such as employment or productivity gains and health benefits due to lower emissions of local pollutants (e.g., nitrogen oxides and sulphur) (Schleich, 2009). We should thus expect that, in economic downturn conditions, firms would be more likely to resort to frugal innovations such as adopting resource efficiency practices in order to reduce their costs.

However, the innovation literature indicates that innovation investments often occur in periods during which a strategic window is opened which is characterized by market growth (Abell, 1978; Lilien and Yoon, 1990). As Freeman et al. (1982) indicate, in adverse market environments, investments are likely to be reduced because of low profit margin and a general "pessimistic mood", while in periods of market expansion there are opportunities for innovation to emerge. We therefore provide two competing hypotheses on the relationship between market conditions and investments in resource efficiency practices.

H1a: Firms will invest less in resource efficiency practices when the market is down.
H1b: Firms will invest more in resource efficiency when the market is down.

As we argue below, market conditions alone cannot determine the success of resource efficiency practices. The adoption of such practices, like the adoption of other strategies undertaken by the firm, need to be associated with capabilities and aligned with the main strategy of the firm. The business strategy literature has highlighted the importance of the fit of a firm's strategy with the environmental or organizational contingencies facing that firm (Andrews, 1971; Hofer and Schendel, 1978), in order to improve firm performance (Ginsberg and Venkatraman, 1985; Miles and Snow, 1994). Recent research has also demonstrated how organizational factors moderate the external economic and regulatory pressures faced by firms and play an important role in the adoption of environmental management practices (Darnall and Edward, 2006; Delmas and Toffel, 2008).

General strategy (strategic fit)

Porter's (1980, 1985) generic business-level strategies, overall cost leadership, differentiation, and focus have become a dominant paradigm in the business policy literature. A cost leadership strategy involves the firm winning market share by appealing to cost-conscious or price-sensitive customers. This is achieved by having the lowest prices in the target market segment. To succeed at offering the lowest price while still achieving profitability and a high return on investment, the firm must be able to operate at a lower cost than its rivals. This is attained by providing high volumes of standardized products and by limiting customization of service. Production costs can be kept low by using fewer components, or standardized components, and by limiting the number of models offered to increase economies of scale. Overheads can be kept low by paying lower wages, by encouraging a cost-conscious culture, and so on. Maintaining this strategy requires a continuous search for cost reductions in all aspects of the business. Because resource efficiency practices should lead to cost reduction, such practices should be more attractive to firms that are pursuing cost leadership strategies than to those pursuing quality or differentiation strategies. We therefore hypothesize that:

H2: Cost leadership strategy oriented firms will be more likely to invest less in resource efficiency practices.

Complementary capabilities

Research has shown that knowledge in one field can ease the absorption of new knowledge in related fields (Cohen and Levinthal, 1990; Delmas, Hoffman and Kuss, 2011). Firms that have developed organizational capabilities to acquire new knowledge in their field will be better able to acquire knowledge related to resource efficiency practices than firms that have not developed such capabilities (Marcus and Geffen, 1998; Darnall and Edwards, 2006). For example, given the conceptual similarity between environmental management systems that aim at reducing the firm environmental impact and resource efficiency that aims at reducing overall resource usage, it may be possible to accelerate the accumulation of resources in the former by integrating it into the latter. In firms that do not have well-developed environmental management systems, there could be barriers to implementing resource efficiency practices, because of a lack of coordination between different units regarding the firm's environmental impact, as well as split incentive problems. Similarly, firms with R&D activities that are conducted in house should also be more prepared to invest in novel resource efficiency practices as they have developed internal capabilities to innovate (Conrad, 1997; McWilliams and Siegel, 2001). We therefore hypothesize the following:

H3a: Firms that have adopted environmental standards are more likely to invest in resource efficiency practices.
H3b: Firms with R&D investments are more likely to invest in resource efficiency practices.

Firm structure

Research has shown that firms with centralized decision-making are more likely to invest in resource efficiency because centralization provides the necessary coordination to resolve the split incentives issues (Howarth and Sanstad, 1995; Sorrell et al., 2004). Vertical integration

of production also reduces transaction costs (Williamson, 1985) and provides opportunities for larger savings from resource efficiency practices. We therefore hypothesize that:

H4: *The more vertically integrated the firm, the more likely will that firm be to invest in resource efficiency practices.*

Market conditions, strategy, complementary capabilities and firm structure

Our framework is summarized in Figure 1. We highlight the role of a firm's external environment, strategies, organizations and resources as drivers of the adoption of resource efficiency practices. Here we argue that investment in frugal innovative strategies such as investments in resource efficiency practices involves and requires a fit between overall cost leadership strategies, market downturn and innovative capacity. Firms that are more likely to invest in resource efficiency practices in downturn market conditions are those that have adopted cost leadership strategies, invested in environmental standards and internal R&D, and are vertically integrated. The combination of these characteristics makes these firms more likely to be able to implement such practices and to benefit from their implementation. We therefore hypothesize the following:

H5a: Cost strategy oriented firms will be more likely to invest less in resource efficiency practices in downturn market conditions as compared to growing market conditions.

H5b: Firms that have adopted environmental standards are more likely to invest in resource efficiency practices in downturn market conditions as compared to in growing market conditions.

H5c: Firms with R&D investments are more likely to invest in resource efficiency practices in downturn market conditions as compared to in growing market conditions.

H5*d*: *The more vertically integrated the firm, the more likely will that firm be to invest in resource efficiency practices in downturn market conditions as compared to in growing market conditions.*

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Insert Figure 1 about here

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4. METHOD

Data

In order to test our hypotheses, we use data from three cross-sectional French surveys: the Organizational Changes and Computerization Survey[1] (COI, 2006), the Community Innovation Survey[2] (CIS8, 2006-2008) and the Annual Firm Survey[3] (EAE, 2006). Our sample includes 5, 877 firms based on merging the data of these three surveys. Although the surveys were administered in 2006, a little before the main worldwide economic recession, France had been in a relatively depressed economic situation for some time at that point, and the surveys provide useful information about the general economic conditions surrounding the firms.

The COI survey is a matched employer-employee dataset on organizational change and computerization. Researchers and statisticians from the National Institute created this survey for Statistics and Economic Studies (INSEE), the Ministry of Labor and the Center for Labor Studies (CEE). The survey covers 7,700 firms from the private sector. This is a representative population of French firms from all industries except agriculture, forestry and fishing. Each firm completed a self-administered questionnaire concerning the utilization of information technologies and work organizational practices in 2006, and concerning changes that had occurred since 2003. Firms were also interviewed on their economic goals and on the economic contexts in which organizational decisions were made.

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[1] More details about the design and scope of this survey are available on www.enquetecoi.net: Survey COI-TIC 2006-INSEE-CEE/Treatments CEE.

[2] More details about the design and scope of this survey are available on http://www.insee.fr/fr/methodes/default.asp?page=sources/sou-enq-communaut-innovation-cis.htm.

[3] More details about the design and scope of this survey are available on http://www.insee.fr/fr/methodes/default.asp?page=definitions/enquete-annuelle-entreprises.htm.

The Community Innovation Survey (CIS) was carried out by the French Institute for Statistics and Economic Studies over the period 2006-2008; the survey is based on the Oslo Manual drawn up by the OECD. Firms answered questions about innovations they had introduced within the past three years.

The Annual Enterprise Survey is an annual survey conducted by the French Ministry of Industry to collect basic data on the structure of surveyed firms such as business activities, size and location. The sample we use comprises 80,000 enterprises.

Dependent Variable

Resource Efficiency Practices. In order to analyze the determinants of investments in energy and resource efficiency practices, we construct a resource efficiency indicator which consists of the following three components: (a) the firm has introduced innovative practices to reduce energy use per unit of output; (b) the firm has introduced innovative practices to reduce material use per unit of output; and (c) the firm has introduced innovative practices to reduce its CO2 'footprint' (total CO2 production). The *resource efficiency practices* variable represents the sum of these components. That is to say, it takes a value of zero if the firm has not adopted any of these practices, a value of 1 if the firm has adopted one of these practices, a value of two if the firm has adopted two of these practices and a value of three if it has adopted all three practices. Therefore, the minimum of the *resource efficiency practices* variable is 0.00 while the maximum is 3.00.[4]

[4] CSI industry questionnaire. Question 11 a. In the last three years, has your firm introduced a product or service innovation, a process or marketing innovation bringing environmental benefits for the production of products or services? (1) Reduction in the use of raw material (including packaging) by unit produced, (2) Reduction of energy consumption by unit produced, (3) Reduction of your firms CO2 emissions.

Independent variables

Market Conditions. In order to examine the impact of market conditions on firms' investments in resource efficiency, we use a variable indicating the evolution of the market conditions of the main activity of the firm since 2003. Three different market conditions are considered: down market conditions (3); steady market conditions (2); and growing market conditions (1). Higher numbers for this variable signify more unfavorable market conditions.

Cost Leadership Strategy. We introduce a continuous variable that represents the level of strategic importance attributed to providing competitively priced products and services. The variable is coded from (1), representing very low strategic importance, to (4), representing very high strategic importance.

Environmental Standards. We include a binary variable, coded (1), if the firm was registered according to one of the following standards in 2006: ISO 14001 standard; organic labeling; fair trade; another type of environment-related standard. Unfortunately, the database does not distinguish between these standards. However, since these standards have similar components, it is expected that their impacts will be similar.

R&D. We introduce binary variable indicating whether the firm undertakes its R&D development activities internally (coded 1) or externally (coded 0).

Vertical Integration. We introduce a binary variable, coded (1), if the firm organizes its production activities internally or if it they are subcontracted.

Controls

Profit. Limited access to capital may prevent resource efficiency measures from being implemented (Jeffe and Stavins, 1994; Kablan, 2003). We include a continuous variable that indicates a firm's profit.

Export. Research has shown firm exports to be a driver in the adoption of green practices (Delmas and Montiel, 2009). We use a continuous variable representing the firm's volume of export divided by the firm's sales.

Regulation. Research has shown that the regulatory context is a significant driver of firm investments in green practices (Kounetas and Tsekouras, 2008; Delmas and Montes-Sancho, 2010). Hence, we include a continuous variable representing whether the firm has been affected by change in regulations, standards (health, environment, worker rights, etc.) since 2003.

Size. Most empirical studies have found that the probability of investing in resource efficiency practices increases with firm size (e.g., Ley, 2010; Kounetas and Tsekouras, 2008; Brunnermeier and Cohen, 2003). Firm size is measured by a continuous variable representing the number of employees within the firm.

Quality Strategy. We introduce a continuous variable that represents the level of strategic importance the firm allocates to the quality of its products or services. The variable is coded from (1), very low strategic importance, to (4) very high strategic importance.

Holding. Being part of a holding company could play an important role in resource efficiency investment. This might be because firms that belong to a holding have more financial resources available for investment in new technologies (Darnall and Edwards, 2006; Pekovic, 2010; Zyglidopoulos, 2002). Hence, we include a dummy variable that takes a value of (1) when the firm belongs to a holding.

Quality Standards. Previous empirical findings support the notion that quality practices positively influence innovation performance, since quality practices, in both their human and technological dimensions, help to create an environment and a culture that support innovation

(Darnall and Edwards, 2006; Pekovic and Galia, 2009). We therefore include a binary variable representing the adoption of quality standards by the firm.

The variables used in estimation, as well as their definitions and sample statistics, are presented in Table 1. No problem of multicolinearity was detected (Appendix 1).

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[Insert Table 1 about here]

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Estimation Strategy

First, using an Ordinary Least Square regression (OLS), we investigate the determinants of a firm's decision to invest in resource efficiency practices. We now have:

$$ln(y)_i = X_i a + e_i \quad (1)$$

where $ln(y)_i$ represents resource efficiency practices; X_1 are the vectors of exogenous variables including vertical integration, regulation, export, cost leadership, quality strategy, QS, ES, R&D, profit, size, holding, sector activity; and finally, e_i is error term.

Second, to investigate resource efficiency investment under different market conditions, we create a dependent variable, denoted *Resource Efficiency x Market Condition*. This variable represents whether investments are realized in down, steady or growing market conditions. On the basis of this classification, we have created a variable *RE1j* that takes the value of *RE1 = 1* if the firm is investing in resource efficiency when the market performance is down, *RE2j* = 2 if the firm is investing in resource efficiency when the market performance is steady, *RE3j* = 3 if the firm is investing in resource efficiency when the market performance is growing and *RE0j* = 0 if a firm is not investing in resource efficiency.

Our analysis will be mainly focused on a firm's decision to invest in resource efficiency practices when the market is down.

We assume that firms choose one of the mutually exclusive alternatives characterized by our categorical variable. This variable reflects four distinct unordered alternatives: Resource Efficiency Investment when market performance is down (alternative $j = 1$), Resource Efficiency Investment when market performance is steady ($j = 2$), Resource Efficiency Investment when market performance is down (alternative $j = 3$) and No Resource Efficiency Investment ($j = 0$). A multinomial logit model was used to evaluate the impact of the firm's characteristics on resource efficiency investments.

In the multinomial logit model, the probability that the firm *i* belongs to the category of investors determined by different market situation *j*, $\forall j = 0, 1, 2, 3,$ is defined by:

$$\text{Prob}(ERE_i = j) = \frac{Exp(x_i\beta_j)}{\sum_{k=0}^{2} Exp(x_i\beta_k)} = \frac{Exp(x_i\beta_j)}{1+\sum_{k=0}^{2} Exp(x_i\beta_k)} \quad (1)$$

where X_i represents the vector of variables for firm *i* (vertical integration, regulation, export, cost reduction, quality strategy, QS, ES, R&D, profit, size, holding, sector activity);

$\beta_1 - \beta_8$ are slope coefficients to be estimated.

5. Results

The descriptive statistics indicate that 58.67 % of the firms in our sample (5, 877 firms) invest in resource efficiency practices divided into 46.71% in energy efficiency, 44.22% in material efficiency, and 38.98% in Co2 efficiency practices. Out of these 3,448 firms, 10.86 % invest in resource efficiency in down market conditions, 27.12%, in steady market conditions and 20.69 % in growing market conditions. Therefore, only 6.3% of our sample invests in resource efficiency practices in downturn market conditions.

The results of the OLS regression and multinomial regressions are presented in Table 2. (The correlation table is presented in Appendix 1.) In the first column, we present the OLS results; the second column shows the results of the determinants of resource efficiency investments when the market is down as compared to no investment; the third column shows the determinants of resource efficiency investment when the market is growing compared to the no investment situation.

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[Insert Table 2 about here]

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In column 1, we observe that the variable representing market conditions is negative and significant, indicating that firms are less likely to invest in resource efficiency when market conditions are worse. The marginal effects indicate that constrained market conditions decrease by 11 points a firm's probability of investing in resource efficiency. This confirms hypothesis H1a but contradicts hypothesis H1b.

Furthermore, as expected, firms showing high values for the variables representing cost leadership strategy, investments in environmental standards and R&D are more likely to invest in resource efficiency practices. This confirms our hypotheses H2 and H3. However, the variable representing vertical integration is not significant and therefore H4 is not confirmed. This might be explained by the fact that vertical integration is only a significant driver in downturn economic conditions (as we will see below) when resources are constrained, but is not a driver in growing economic conditions.

Turning to the control variables, we find that larger firms, with higher shares of exports, that are undertaking quality strategies and have adopted quality standards, are also more likely to invest in resource efficiency practices. This confirms previous studies (e.g., Darnall and

Edwards, 2006; Schleich, 2009; Pekovic and Galia, 2009; Porter and Van der Linde, 1995; Conrad, 1997; Malueg, 1989; Van Raaij and Verhallen, 1983). Indeed, quality strategies in conjunction with resource efficiency strategies might result in more efficient and functional products and services. The results, regarding the lack of significance of our variable representing regulation, are consistent with those of Del Río and Tarancón (2005), indicating that market variables tend to be a more significant driver than regulations in facilitating the adoption of environmental regulation. This result could also be attributed to the context of the study: France a single and very centralized country, and might not exhibit enough regulatory variation to be adequately representative.

Regarding the determinants of resource efficiency investments when the market is down, compared to the no investment situation (the second column of Table 2), we observe that cost leadership strategy, environmental standards and internal R&D are significant predictors of investments in resource efficiency practices. This confirms hypothesis H5 a, b, and c. Similarly, the variable representing vertical integration is positively related to investments in resource efficiency practices, and this confirms our hypothesis H5d. Overall firms with cost leadership strategy, internal R&D, environmental standards and that are vertically integrated are 20% more likely to adopt resource efficiency practices.

Turning to the control variables, larger firms, and firms belonging to a holding are more likely to invest in resource efficiency practices, indicating some potential economies of scale associated with the adoption of such practices. Furthermore, export negatively influences a firm's probability of investing in resource efficiency when the market is going down.

The third column (Table 2) represents the results related to the determinants of resource efficiency investment when the market is growing, comparing to a no investment situation. Export, cost leadership, quality strategy, quality standards, environmental standards, R&D and size are significant, as in the results of the OLS estimates (first column). This is not

surprising, since these investments represent a larger share of the overall investments. Additionally, profit positively influences a firm's probability of investing in resource efficiency when the market is growing compared to the situation in the no investment situation.

Our data reveals significant evidence of differing investment behavior towards resource efficiency, according to market conditions. Our results yield a number of interesting findings that help us better understand the relationships between market conditions, firm strategy and organization.

Several versions of the model have been investigated to confirm the robustness of our results (Appendix 2). These include an independent estimation of each of the indicators of resource efficiency -- namely, reduced energy, material and CO2 footprint -- in four different market situations. The results of this investigation do not indicate any significant conflict with our main findings.

6. DISCUSSION AND CONCLUSION

The aim of this paper has been to broaden our understanding of the kind of firm-level resources and capabilities that are needed to develop models of frugal innovation that do more with less. In the context of resource efficiency practices, our findings indicate that models of frugal innovation encompass a combination of various firm capabilities and strategies, which impact the likelihood of successful adoption of such innovations. We show that firms are more likely to invest in resource efficiency practices in downturn market conditions if they are focusing their main strategy on cost leadership, if they have also adopted environmental standards, if they have invested in R&D, and if they are vertically integrated and of larger size.

Our results complement the existing literature; it has been found that depressed market conditions reduce a firm's willingness to invest in innovation (e.g., Kanerva and Hollanders, 2010). However, while, on the whole, a firms' investment in innovation declines during a market downturn, a small but significant minority of firms is "swimming against the stream" and increasing their investments (Filippetti and Archibugi, 2011). Such firms seek opportunities to invest *more* in constrained economic times, by developing strategies that are environmentally and economically oriented. Our results show the characteristics of such firms in the context of resource efficiency investments.

Our results indicate that investments in resource efficiency practices are not conducted in isolation, but are part of a grouping of practices and strategies that potentially reinforce each other. Business models in downturn economic conditions are therefore significantly different from those in economically growing conditions, where resources are more readily available. This article builds on the literature analyzing the organizational factors that impact the adoption of environmental practices (Darnall and Edward, 2006; Delmas and Toffel, 2008). It shows that firms adopt different environmental strategies even when they are facing the same depressed economic conditions. The reason for these differences lies into differences in firms' organizational structures and resources. This research demonstrates the importance of opening the organizational black box to understand firm behavior.

Our results have significant policy implications. Policymakers seeking to encourage corporations to reduce energy and resource use should infuse firms with a comprehensive set of practices, rather than focusing solely on energy or resource efficiency. The United Nations Environmental Program (UNEP), as part of its resource efficiency program, is investing close to three billion dollars in demonstrating to public and private sector decision-makers that there is a case to be made for resource efficiency, and in supporting entrepreneurial innovations. UNEP recognizes that managers tend to consider resource efficiency investments as

« "environmental" i.e. add-on interventions not related to core business and market competitiveness ».[5] Our research confirms the need to focus on the synergies between a firm's objectives and its resource efficiency investments. This includes attention to the development of market signals to promote changes in consumer behavior, along with the delivery of guidance and training to improve the application of new tools.

Our research is not without limitations. First, our analysis was limited to the French context; future research should explore similar questions in an international setting, as scholars have identified international institutional differences regarding the implementation of environmental practices (Husted, 2005; Husted and Allen, 2006; Darnall et al., 2008; Delmas and Montiel, 2008; Delmas and Montes-Sancho, 2011). Second, while our database included a rich set of variables that allowed us to control for many organizational characteristics, its cross- sectional nature hampered us from conducting a dynamic analysis. Further research should examine whether the effects identified in this study persist over time, and should further investigate the precise nature of the dynamic interactions between the firm external environment, its main business strategy, resources and organization, and investments in resource efficiency.

[5] http://dewa03.unep.org/pow2010/621

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Table 1: Definition of variables and sample statistics

Variable	Description	Mean	SD	Min	Max
Resource Efficiency*	The firm has reduced energy use per unit of output, reduced material use per unit of output and reduced CO2 'footprint' (total CO2 production) (Continuous variable)	1.30	1.26	0.00	3.00
Market Condition**	How the market of the main activity of the firm has evolved since 2003: DOWN (=3 if yes) STEADY (=2 if yes) GROWING (=1 if yes) (Continuous variable)	2.10	0.72	1.00	3.00
Resource Efficiency x Market Condition	ERE1 = 1 investment in innovative resource efficiency practices when market performance is down; ERE2 = 2 investment in innovative resource efficiency practices when market performance is steady; ERE3 = 3 investment in innovative resource efficiency practices when market performance is growing; ERE0 = 0 no investment in innovative resource efficiency practices	2.92	1.06	1.00	4.00
Energy Efficiency*	The firm has reduced energy use per unit of output Dummy variable (=1 if yes)	0.47	0.50	0.00	1.00
Material Efficiency*	The firm has reduced material use per unit of output Dummy variable (=1 if yes)	0.44	0.50	0.00	1.00
CO2 Efficiency*	The firm has reduced CO2 'footprint' (total CO2 production) Dummy variable (=1 if yes)	0.40	0.49	0.00	1.00
CONTROL VARIABLES					
Export***	The share of exports of total sales (€) (Continuous variable)	0.19	0.27	0.00	1.00
Regulation**	Since 2003, the firm has been affected by change in regulations, standards (health, environment, worker rights, etc.) (Continuous variable)	0.27	0.82	1.00	4.00
Cost Leadership Strategy**	Strategic importance to competitive priced products and services (Continuous variable)	3.35	0.64	1.00	4.00

Variable	Description	Mean	SD	Min	Max
Quality Strategy**	Firm's importance for quality strategy for product, service and performance (Continuous variable)	3.62	0.53	1.00	4.00
QS**	Registered with ISO 9000, EAQF, etc. Dummy variable (=1 if registered in 2006)	0.72	0.45	0.00	1.00
Environmental Standards**	Registered for ISO 14001, organic labeling or fair trade Dummy variable (=1 if registered in 2006)	0.40	0.49	0.00	1.00
R&D*	The R&D development activities were realized internally or externally Dummy variable (=1 if yes)	0.56	0.50	0.00	1.00
Vertical Integration**	The production is organized at internal level Dummy variable (=1 if yes)	0.88	0.33	0.00	1.00
Profit***	The firm's profit (€) (Continuous variable)	4209 5.49	34399 4.3	-571691	6619330
Size**	Number of employees	2727. 59	9824. 865	18.00	111956.00
Holding**	Belong to a holding group Dummy variable (=1 if yes)	0.83	0.37	0.00	1.00
Sector**	Agrifood, consumption goods, cars and equipment, intermediate goods, energy, construction, commercial, transport, financial and real-estate activities, business services and individual services				

[a]: Because of the table's length we do not report sample statistics for these variables

* variables were retrieved from the CIS database; ** variables retrieved from the COI database ;*** variables retrieved from the EAE database.

Table 2a: The Determinants of Energy Resource Efficiency

VARIABLES	(1) Resource Efficiency Investment	(2) Resource Efficiency x Market Down (reference no Investment)	(3) Resource Efficiency x Market Grow (reference no Investment)
	OLS Model	Multinomial Model	
Market Condition	-0.08***		
	(0.020)		
Export	0.29***	-0.97***	0.65***
	(0.067)	(0.247)	(0.187)
Regulation	-0.03	0.07	0.01
	(0.018)	(0.059)	(0.051)
Cost Leadership Strategy	0.12***	0.41***	0.33***
	(0.023)	(0.079)	(0.069)
Quality Strategy	0.07***	0.14	0.20**
	(0.027)	(0.092)	(0.081)
QS	0.24***	0.06	0.76***
	(0.037)	(0.121)	(0.115)
Environmental Standards	0.31***	0.44***	0.38***
	(0.033)	(0.110)	(0.094)
R&D	1.00***	1.53***	2.10***
	(0.032)	(0.109)	(0.100)
Profit	0.00	-0.00	0.00***
	(0.000)	(0.000)	(0.000)
Vertical Integration	-0.05	0.40***	-0.02
	(0.045)	(0.156)	(0.136)
Size	0.00***	0.00**	0.00**
	(0.000)	(0.000)	(0.000)
Holding	0.05	0.46***	0.16
	(0.039)	(0.142)	(0.116)
Agrifood	-0.16***	0.07	-0.77***
	(0.058)	(0.176)	(0.187)
Consumption goods	0.13*	0.05	0.37**
	(0.065)	(0.212)	(0.180)
Cars and equipment	-0.30***	-0.20	-0.47***
	(0.050)	(0.164)	(0.137)
Energy	0.34***	-0.64	0.71**
	(0.099)	(0.490)	(0.312)
Construction	0.54***	-0.91***	1.29***
	(0.070)	(0.347)	(0.194)
Commercial	0.14**	0.59***	-0.10
	(0.056)	(0.176)	(0.185)
Transport	0.45***	0.00	1.51***
	(0.065)	(0.244)	(0.176)
Financial and real estate	0.66***	-13.12	2.46***

VARIABLES	(1) Resource Efficiency Investment	(2) Resource Efficiency x Market Down (reference no Investment)	(3) Resource Efficiency x Market Grow (reference no Investment)
	OLS Model	Multinomial	Model
	(0.105)	(336.018)	(0.286)
Services for firms	-0.11**	-0.59***	0.32**
	(0.053)	(0.194)	(0.151)
Services for individuals	0.32***	0.37	0.83***
	(0.088)	(0.270)	(0.259)
Constant	-0.14	-4.96***	-5.01***
	(0.139)	(0.469)	(0.406)
R2	0.289		
Correctly classified		80.83%	79.74%
Observations	5877	5,877	5,877

(*), (**), (***) indicate parameter significance at the 10, 5 and 1 per cent level, respectively.

Appendix 1: Pearson correlation coefficients (As for Tables 1, we do not report results concerning the variable ACTIVITY)

	Resource Efficiency	Resource Efficiency x Market Condition	Market Condition	Export	Regulation	Cost Leadership strategy	Quality Strategy	QS	Environmental standards	R&D	Profit	Vertical Integration	Size	Holding
Resource Efficiency	1.00	-	-	-	-	-	-	-	-	-	-	-	-	-
Resource Efficiency x Market Condition	0.87	1.00	-	-	-	-	-	-	-	-	-	-	-	-
Market Condition	-0.14	0.22	1.00	-	-	-	-	-	-	-	-	-	-	-
Export	0.22	0.17	-0.09	1.00	-	-	-	-	-	-	-	-	-	-
Regulation	0.02	0.01	-0.01	-0.07	1.00	-	-	-	-	-	-	-	-	-
Cost Leadership strategy	0.15	0.14	0.04	0.19	0.10	1.00	-	-	-	-	-	-	-	-
Quality Strategy	0.10	0.08	-0.06	0.10	0.12	0.16	1.00	-	-	-	-	-	-	-
QS	0.25	0.19	-0.13	0.27	0.04	0.11	0.13	1.00	-	-	-	-	-	-
Environmental Standards	0.29	0.23	-0.04	0.31	0.05	0.16	0.09	0.41	1.00	-	-	-	-	-
R&D	0.47	0.38	-0.13	0.38	-0.01	-0.16	0.11	0.27	0.27	1.00	-	-	-	-
Profit	0.11	0.04	-0.10	-0.01	0.04	-0.01	0.06	0.06	0.09	0.09	1.00	-	-	-
Vertical Integration	0.03	0.04	0.02	0.07	0.03	0.06	0.03	0.15	0.06	0.09	-0.12	1.00	-	-
Size	0.15	-0.10	-0.06	0.01	0.12	0.07	0.06	0.09	0.16	0.10	0.60	-0.13	1.00	-
Holding	0.11	0.10	0.00	0.15	-0.02	0.12	0.08	0.18	0.18	0.12	0.02	-0.01	0.04	1.00

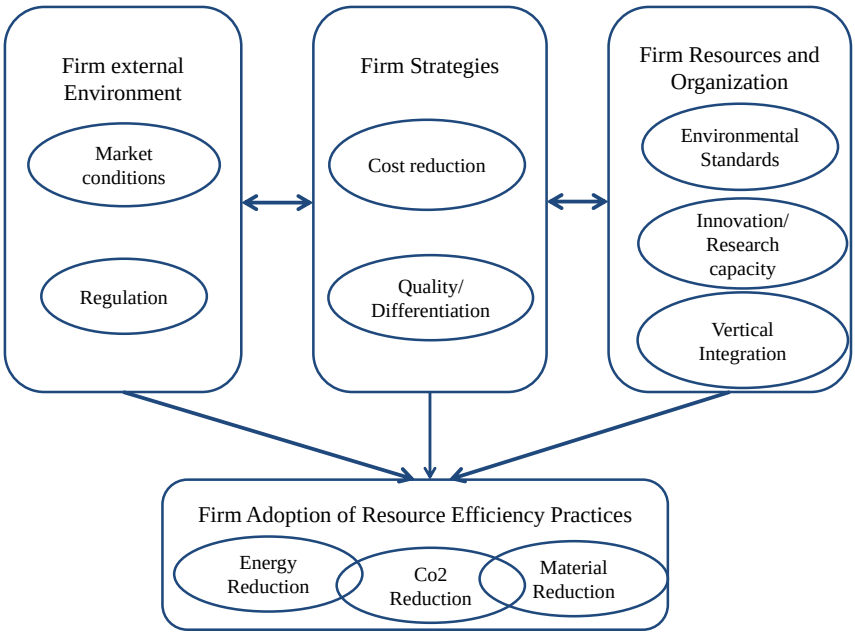
Appendix 2: The Determinants of Energy Resource Efficiency sub-measure under Different Market Conditions

VARIABLES	(1) Energy Efficiency Investment vs No Investment	(2) Energy Efficiency x Market Down vs No Investment	(3) Energy Efficiency x Market Grow vs No Investment	(4) Material Efficiency Investment vs No Investment	(5) Material Efficiency x Market Down vs No Investment	(6) Material Efficiency x Market Grow vs No Investment	(7) CO2 Efficiency Investment vs No Investment	(8) CO2 Efficiency x Market Down vs No Investment	(10) CO2 Efficiency x Market Grow vs No Investment
Market Condition	-0.15***			-0.13***			-0.13***		
	(0.04)			(0.04)			(0.04)		
Export	0.54***	-0.72***	0.84***	0.46***	-0.87***	0.73***	0.31**	-0.89***	0.36*
	(0.14)	(0.257)	(0.182)	(0.14)	(0.259)	(0.182)	(0.14)	(0.295)	(0.195)
Regulation	-0.16***	-0.06	-0.06	-0.06	-0.01	0.09*	0.07*	0.22***	0.13**
	(0.04)	(0.066)	(0.052)	(0.04)	(0.066)	(0.053)	(0.38)	(0.073)	(0.055)
Cost Leadership Strategy	0.24***	0.33***	0.22***	0.20***	0.36***	0.10	0.19***	0.17*	0.23***
	(0.05)	(0.090)	(0.071)	(0.05)	(0.091)	(0.071)	(0.05)	(0.098)	(0.076)
Quality Strategy	0.12**	0.16	0.21**	0.21***	0.01	0.41***	0.01	0.32**	-0.01
	(0.06)	(0.104)	(0.083)	(0.06)	(0.100)	(0.087)	(0.06)	(0.123)	(0.087)
QS	0.44***	0.19	0.90***	0.57***	0.36**	0.80***	0.31***	0.07	0.89***
	(0.08)	(0.142)	(0.123)	(0.08)	(0.146)	(0.127)	(0.08)	(0.152)	(0.137)
Environmental Standards	0.42***	0.41***	0.26***	0.65***	0.77***	0.58***	0.36***	0.09	0.43***
	(0.07)	(0.120)	(0.093)	(0.07)	(0.120)	(0.095)	(0.07)	(0.136)	(0.099)
R&D	1.66***	1.19***	1.72***	1.59***	1.22***	1.68***	1.64***	1.14***	1.70***
	(0.07)	(0.123)	(0.103)	(0.07)	(0.123)	(0.105)	(0.08)	(0.138)	(0.112)
Profit	0.00	-0.00***	0.00	0.00***	-0.00***	0.00***	0.00	-0.00***	0.00**
	(0.00)	(0.000)	(0.000)	(0.00)	(0.000)	(0.000)	(0.00)	(0.000)	(0.000)
Vertical Integration	0.13	0.65***	-0.30**	-0.26***	0.04	-0.53***	-0.13	0.06	-0.42***
	(0.10)	(0.196)	(0.133)	(0.10)	(0.177)	(0.135)	(0.10)	(0.185)	(0.141)
Size	0.00***	0.00***	0.00***	-0.00	0.00	-0.00***	0.00***	0.00***	0.00***
	(0.00)	(0.000)	(0.000)	(0.00)	(0.000)	(0.000)	(0.00)	(0.000)	(0.000)
Holding	0.08	0.09	0.03	0.10	0.13	0.08	0.14	0.33*	0.05

	(0.09)	(0.153)	(0.119)	(0.09)	(0.157)	(0.124)	(0.09)	(0.180)	(0.128)
Agrifood	-0.06	0.20	-0.80***	-0.08	0.08	-0.74***	-0.60***	-0.65***	-1.32***
	(0.12)	(0.183)	(0.203)	(0.12)	(0.192)	(0.193)	(0.13)	(0.237)	(0.243)
Consumption goods	0.13	0.04	0.45**	0.56***	0.56**	0.66***	0.05	-0.20	0.40**
	(0.14)	(0.227)	(0.177)	(0.14)	(0.221)	(0.179)	(0.14)	(0.259)	(0.186)
Cars and equipment	-0.46***	-0.11	-0.41***	-0.36***	0.02	-0.39***	-0.65***	-0.24	-0.68***
	(0.10)	(0.168)	(0.134)	(0.10)	(0.168)	(0.134)	(0.10)	(0.189)	(0.145)
Energy	1.16***	-0.05	1.36***	-0.39*	-1.53***	-0.76**	1.11***	-0.62	1.23***
	(0.25)	(0.481)	(0.288)	(0.21)	(0.542)	(0.294)	(0.23)	(0.629)	(0.276)
Construction	1.27**	-0.45	1.75***	0.25*	-1.89***	0.71***	1.29***	-0.34	1.72***
	(0.16)	(0.347)	(0.189)	(0.15)	(0.476)	(0.185)	(0.15)	(0.364)	(0.190)
Commercial	0.22*	0.39**	-0.36*	0.27***	0.36*	-0.23	0.36***	0.34	-0.30
	(0.12)	(0.191)	(0.196)	(0.12)	(0.197)	(0.188)	(0.13)	(0.211)	(0.208)
Transport	1.11***	-0.21	1.61***	0.02	-0.69**	0.30	1.32***	0.26	1.85***
	(0.14)	(0.286)	(0.175)	(0.14)	(0.295)	(0.189)	(0.14)	(0.269)	(0.181)
Financial and real estate	1.97***	-14.41	2.58***	0.18	-14.37	0.57*	1.30***	-14.56	1.79***
	(0.23)	(708.765)	(0.281)	(0.24)	(478.115)	(0.304)	(0.22)	(667.323)	(0.298)
Services for firms	-0.34***	-1.39***	0.02	-0.05	-0.48**	0.09	-0.25**	-1.23***	0.06
	(0.12)	(0.258)	(0.153)	(0.12)	(0.211)	(0.153)	(0.12)	(0.268)	(0.163)
Services for individuals	0.92***	0.17	1.05***	0.28	-0.42	0.32	0.59***	0.10	0.95***
	(0.19)	(0.322)	(0.260)	(0.19)	(0.383)	(0.277)	(0.19)	(0.315)	(0.269)
Constant	-2.68***	-4.85***	-4.63***	-2.97***	-4.32***	-5.04***	-2.78***	-5.40***	-4.63***
	(0.30)	(0.531)	(0.414)	(0.31)	(0.516)	(0.429)	(0.31)	(0.599)	(0.436)
Observations	5,877	5,877	5,877	5,877	5,877	5,877	5,877	5,877	5,877

(*), (**), (***) indicate parameter significance at the 10, 5 and 1 per cent level, respectively.

Figure 1.


Firm external Environment
Market conditions
Regulation
Firm Strategies
Cost reduction
Quality/ Differentiation
Firm Resources and Organization
Environmental Standards
Innovation/ Research capacity
Vertical Integration
Firm Adoption of Resource Efficiency Practices
Energy Reduction
Co2 Reduction
Material Reduction