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Sandra CAVACO
Patricia CRIFO

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DEPARTEMENT D'ECONOMIE
Route de Saclay
91128 PALAISEAU CEDEX
(33) 1 69333033
http://www.economie.polytechnique.edu/
mailto:chantal.poujouly@polytechnique.edu

The CSR-Firm Performance Missing Link: Complementarity Between Environmental, Social and Business Behavior Criteria? *

Sandra Cavaco† and Patricia Crifo‡

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Abstract

This article analyzes the relationship between corporate social responsibility (CSR) and firm performance by proposing a theoretical model and by testing empirically its main predictions on a matched panel database for the biggest European listed firms over the 2002-2007 period. Our dataset gathers two sources of information: environmental, social and governance (ESG) ratings from the Vigeo database, and economic and financial performance data from the Orbis database. Using the System GMM estimator for dynamic panel data model, we test the complementarity and substitutability, that is the super- and sub- modularity between various corporate social responsibility practices, along with its impact on firm performance. We do observe that a complementarity premium on specific CSR dimensions (human resources and business behavior towards customers and suppliers) exists but also that some practices are relative substitutes (environment and business behaviors).
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†LEM, University Paris II Pantheon-Assas and CPP, Aarhus School of Business. sandra.cavaco@u-paris2.fr.

‡University Paris X, École Polytechnique and IRES, Catholic University of Louvain. patricia.crifo@polytechnique.edu.

1 Introduction

This article examines the effects of corporate social responsibility (CSR) on firm performance. A considerable attention has been given to this issue for the past three decades, especially in management sciences and organizational economics, but no consensus has emerged so far on whether corporate social responsibility (CSR) leads or not to superior performance[1]. Do CSR strategies improve performance or, are they costly CSR practices adopted by firms where performance is already high or, where these practices are most likely to improve performance?

Being socially responsible means that, beyond legal constraints, firms commit on a voluntary basis to bear the cost of a more ethical behavior (European Commission, 2001).[2] For instance, CSR strategies imply to improve employment conditions and/or ban child labor in countries that do not respect human rights, protect the environment and invest in abatement equipment to reduce carbon footprint, develop partnerships with NGOs, or provide funds to charity, etc. Therefore, CSR is inherently multi-faceted and it is crucial to understand why some businesses adopt these practices while others do not as well as which types of practices are more profitable. This article helps answer these questions by investigating which combinations (or clusters) of CSR strategies are most likely to improve firm performance.

To examine the impact of clusters of CSR practices on firm performance, we propose a theoretical model and test its main predictions on a rich data panel set of CSR and performance indicators for the biggest European listed firms during the 2002-2007 period.

Our theoretical model formalizes CSR decisions as a multi-tasks agency problem with moral hazard in which shareholders delegate CSR to managers, with the CSR tasks being evaluated exogenously by an extra-financial rating agency. More precisely, on each CSR task, the firm may receive a rating either above or below sectoral average. Extra-financial evaluations are exogenous and publicy observed by both parties. The impact of CSR decisions on firm performance then depends on the degree of complementarity between the different CSR tasks. Given the extra-financial evaluation, two CSR tasks are complementary when the cost of effort in one CSR task decreases when another CSR task is implemented[3]. We show that extra-financial ratings have a positive impact on CSR efforts when at least two pairs of CSR tasks are complementary. When only one pair of CSR tasks is complementary (and/or another one is substitutable) then CSR ratings have an ambiguous

[1]For a review of results from these empirical studies see Margolis and Walsh (2003) or Margolis, Elfenbein and Walsh (2007).

[2]In 2005, 52% of the top 100 corporations in the 16 more industrialized countries published a report on their corporate and socially responsible (CSR) activities (Becchetti et al. 2005a). In the U.S, 1 dollar out of 9 invested on financial markets in 2007 embedded a dimension of CSR (11%), 3% in France and nearly 4% in Europe (EFAMA 2008 and Euro SIF 2008).

[3]In other words, two or more tasks are complements when using one more intensely increases the marginal benefit of using others more intensively (see Milgrom and Roberts, 1995). In our model, this characteristics is formalized in terms of cost complementarity.

impact on CSR efforts and firm performance. Hence, we show that the impact of CSR ratings on firm performance depends on the degree of complementarity or substitutability between the different CSR tasks.

The main predictions of our model are then tested on a matched CSR-Firm performance database panel of the biggest European listed firms over the 2002-2007 period. We examine whether CSR is positively correlated with firm performance and how the complementarity or substitutability between the CSR tasks affects this relationship, given the extra-financial ratings.

In our dataset, the CSR variables consist in ratings attributed by the French environmental and social rating agency Vigeo over 3 broad domains of firms' corporate social responsibility: human resources, environment, and business behavior towards customers and suppliers.

The firm performance variables come from the Orbis database (Bureau Van Dijk) and consist in detailed information from the companies' standardized annual accounts (cash flow, operating ratios, total assets, profitability ratios etc.).

A simple analysis on the Vigeo database reveals that the distribution of correlation among environmental, human resources and business behavior ratings shows positive correlations between these dimensions. This pattern is clearly consistent with the idea that corporate social responsibility, decomposed into environmental, social and business behavior factors, would be complementary inputs of firm performance. To estimate the links between CSR and firm performance, we exploit the dynamic dimension of our dataset through the System GMM (Generalized Method of Moments) technique and estimate the impact of CSR practices on firm performance. Then we test explicitly the complementarity between environmental, human resources and business behaviors, and determine which pairs of practices are complementary or substitutable inputs of firm performance. We do observe that some practices are complementary (human resources and business behavior towards customers and suppliers), but other CSR dimensions are also substitutes (environment and business behaviors).

This paper is organized as follows. Section 2 presents a synthetic review of the literature on the links between CSR and firm performance. Section 3 develops the theoretical model and its main theoretical predictions. The data and variables are presented in section 4. The empirical methodology and results are developed in section 5. Section 6 concludes the article.

2 Brief Review on the CSR-Firm Performance Link

Many reasons in the literature are invoked to explain the prevalence of CSR strategies: shrinking role of governments, society's demands for greater disclosure and increased consumers' interest in CSR, growing investor pressure, competition on labor markets for competent and motivated employees, increasing risks associated with unethical behaviors, importance of taking into account relationships with suppliers, external pressure from the civil society, etc. CSR strategies would in fact allow firms to maximize value and to minimize risk in the long run in order to respond to an increased competitive pressure and market differentiation. Such strategies would more generally allow taking into account the growing demands of their stakeholders (customers, consumers, employees, savers). According to Benabou and Tirole (2010), these arguments capture three alternative visions of CSR. In the first vision, CSR would be a 'win-win' strategy whereby CSR would make a firm profitable. This vision is also known as the 'Porter hypothesis' or 'doing well by doing good' (see Porter and van der Linde, 1995 and Porter and Kramer, 2002). In the second vision, CSR would be equivalent to delegated philanthropy, the firm being a channel for the expression of citizen values. Under both vision 1 and 2, profit maximization and CSR are consistent. The third vision interprets CSR as insider-initiated corporate philanthropy, not motivated by stakeholders' demand but rather reflecting management's own desire to engage in philanthropy. In this case, profit is then not maximized. Here, we focus on strategic CSR, that is on CSR as a strategic decision designed to improve firm performance and examine which combinations of CSR practices most likely increase profitability.

The **theoretical literature** on the determinants of strategic CSR decisions focuses on various aspects of a firm's CSR strategy. A large number of articles consider CSR as a product differentiation strategy (see among others Baron (2007, 2008), Besley and Ghatak (2007), Graff Zivin and Small (2005), Becchetti et al. (2005 a and b), Manasakis et al. (2007)). Other approaches, for instance Baron (2009), Bagnoli and Watts (2003) or Heyes and Maxwell (2004), consider CSR as a private provision of a public good or as moral duty to undertake social activities and analyze interactions between firms, NGOs and/or regulators (in particular preemption behaviors, see Lyon and Maxwell, 2004)). Focusing on strategic CSR, Cespa and Cestone (2008) formalize CSR decision as stakeholder protection and managerial entrenchment.

These models on the determinants of strategic CSR adoption are compatible with the 'Porter hypothesis'. Each model offers a very insightful analysis of a specific dimension of a firm's CSR strategy and its impact on equilibrium prices, profits and/or welfare. However, the definition of CSR practices varies from one model to another, without explicitly decomposing CSR strategies into multiple dimensions such as for instance environement, human resources and business behaviors. Our contribution to the theoretical literature on the links between strategic CSR and

firm performance is thus twofold. On one hand, we propose a model where CSR decisions are made over $n \geq 2$ dimensions, which enriches existing approaches often focusing on one particular dimension of a firm's CSR policy. By formalizing CSR investments over multiple dimensions our model may therefore be considered as complementary to these approaches. As pointed out by Benabou and Tirole (2010), the different dimensions of CSR need to be considered, since firms can do well in some dimensions and poorly on others. On another hand, the second originality of our model is to consider explicitly the impact of ratings in the CSR decision process and allow analyzing, within a simple partial equilibrium model, the impact of extra-financial ratings on CSR decisions and expected profits.

There is a considerable **empirical literature** on the impact of strategic CSR decisions on firm performance. However, there is no consensus on the link between CSR and firm performance and on the empirical validity of the 'Porter hypothesis' (for a survey see e.g. Baron et al. 2008; Margolis et al. 2007; Forget, 2010). Recent research points at numerous biases and problems of previous work (eg: Elsayed and Paton, 2005 or McWilliams and Siegel, 2000) among which: model misspecification (endogeneity), omitted variables in the determinants of profitability, limited data (small samples, old periods), cross-sectional analysis invalid in the presence of significant firm heterogeneity, problems of measurement of CSR, wide diversity of measures used to assess financial performance. Another problem also lies in the direction and mechanisms of causation. Whether corporate social responsibility would lead (or not) to superior firm performance, or whether financial performance would rather be a necessary condition for corporate social responsibility is still a major stake to be investigated.

In this paper, we consider that the absence of consensus on the links between corporate social responsibility - and intangible assets in general - and firm performance suggests that it should be a specific combination of firm policies that would likely lead to superior corporate performance. During the 1990s, this complementarity between different managerial practices has proven a useful explanation of the Solow paradox, whereby "you can see the computer age everywhere but in the productivity statistics" (Solow, 1987). Indeed, several researchers have shown that only those firms that have adopted both computerization and complementary innovative human resources management practices (teamwork, multi-tasking, quality circles, etc.) did enjoy superior performance (see e.g. Ichniowski and Shaw 2003; Boucekkine and Crifo, 2008). By analogy, the apparently ambiguous link between CSR and firm performance could presumably be explained by taking into account the complementarity between the multi-dimensional facets of corporate social responsibility.

Our contribution to the empirical literature on the links between strategic CSR investments and firm performance is twofold. On the one hand, by exploiting the temporal dimension of our database through the System GMM (Generalized Method of Moments) technique (see Blundell and Bond, 1998), we better account for the dynamics of the CSR-firm performance relationship. On the other hand, we also propose an explicit test of the complementarity between the different dimensions

of CSR strategies. We are therefore able to determine which combination of CSR practices is most likely to improve firm performance.

Several papers have already addressed the dynamics of the CSR-firm performance relationship. For instance, Paton and Elsayed (2005) propose an estimation of the links between CSR and performance relying on dynamic estimation techniques. However, they do not analyze how the complementarity between the different dimensions of CSR activities affects this relationship. Similarly, Baron et al. (2008) provides an empirical test of a positive theory of corporate social performance (CSP) and its relation to corporate firm performance (CFP) and to social pressure. They show notably that greater CSP results in economically and statistically significant better CFP, and social pressure reduces CFP. This approach provides a comprehensive analysis of the relations among CFP, CSP, and social performance. In particular, in an original and innovative empirical strategy, CSP is disaggregated into strategic components likely to increase revenue or productivity directly and components likely to be a response to social pressure. Our paper explores a different but complementary link between CSR and performance. In fact, we focus on the complementarity between the mutliple dimensions of a firm's CSR policy, and analyze its impact on firm performance.

3 The Theoretical Model

3.1 Basic Set-Up

The economy is composed of a continuum of mass one of risk-neutral shareholders and a continuum of mass one of risk-averse managers. Managers are randomly matched one-to-one with shareholders in a principal-agent relationship with moral hazard (imperfect observability of the manager's effort). Shareholders delegate CSR activities to managers and the firm's CSR tasks are evaluated exogenously by an extra-financial rating agency. The rating of the extra-financial agency is exogenous and publicly observed by both parties before effort decisions are made. A firm's overall CSR strategy is defined as follows.

Definition 1.
Corporate social responsibility has several dimensions, comprising:

- **An Environmental Component**

This dimension refers to the incorporation of environmental considerations into the design, manufacturing and distribution of products: pollution prevention and control, protection of water resources, biodiversity, waste management, management of local pollution, management of environmental impacts from transportation etc.

- **A Human Resources (or Social) Component**

This dimension refers to responsible human resources management (training and career development, employee participation, quality of working conditions etc.) and may include as well contributions to local and general interest causes, respect for human rights, elimination of child labor.

- **A Business Behaviors and Governance Component**

This dimension refers to the firms' practices towards customers and suppliers (prevention of conflicts of interest, corruption or anti-competitive practices[4]*, product safety, information to consumers, integration of CSR in the supply chain etc.) and shareholders (shareholders' rights, promotion of independent and competent administrators and auditors, transparency of compensation policy of key executives.)*

Decomposing CSR into $n \geq 2$ dimensions is consistent with and complementary to existing approaches, either theoretical and focusing on one broad dimension of CSR at the firm level[5], or empirical and capturing different criteria of CSR strategies[6]

The production process consists of n CSR tasks, which are delegated by shareholders (who own production) to managers. This assumption is consistent with shareholders' support for explicit stakeholder protection leading them to endorse explicit CSR measures possibly because they fear costly boycotts (see Cespa and Cestone (2007). The manager's effort is imperfectly observable and shareholders have to design a contract that helps solving the moral hazard problem. [7] The incentives structure of the model corresponds to the linear-exponential-normal (LEN) multi-tasks agency framework first developed by Holmstrom and Milgrom (1987, 1991) where managers have a negative exponential utility (see e.g. Itoh, 1994 or Feltham and Xie, 1994).[8]

[4]Such practices are for instance encouraged by international organizations such as the United Nations, OECD or World Trade Organization.

[5]For instance, the firm's CSR policy may be formalized as a product differentiation strategy (see e.g. Graff Zivin and Small, 2005 or Baron 2007, 2008a and b) or as a broader notion of stakeholder protection (see Cespa and Cestone, 2007). Our definition of CSR therefore complements such types of approaches.

[6]For instance, in their meta-analysis of 167 studies on the links between CSR and firm performance, Margolis, Elfenbein and Walsh (2007) consider nine categories of CSR strategies: Charitable contributions, Corporate policies, Environmental performance, Revealed misdeeds, Transparency, and four other categories reflecting different ways researchers attempt to capture firms CSR (Self-reported social performance, Observers' perceptions, Third-party audits and Screened mutual funds). Our approach is consistent with such type of studies, as we consider several categories of CSR tasks in our theoretical and empirical analysis.

[7]The conflict of interests between shareholders and managers relies on the moral hazard issue associated with imperfect observability of managerial CSR efforts. In a very interesting analysis, Cespa and Cestone (2007) formalize another determinant of this conflict of interests, relying on managerial entrenchment considerations. Our approach differs from Cespa and Cestone's model because we do not formalize social activists' interest for CSR issues.

[8]This model has been extensively used to analyze multi-tasks agency relationships under the assumption of constant absolute risk aversion.

More precisely, our model extends Itoh (1994)'s framework with n effort levels (or tasks).

The observable output of the relationship between the shareholder and the manager is given by:

$$y = \sum_{i=1}^{n} .e_i + \epsilon \tag{1}$$

where e_i represents unobservable effort at CSR task i and ϵ is an error term (random noise capturing imperfect observability of effort) normally distributed with mean zero and variance $\sigma^2 > 0$.[9]

The shareholder is risk neutral and the manager is risk averse with preferences represented by the exponential utility function as follows: for any managerial income ω (payment received minus cost of effort) the manager's utility function is:
$u(\omega) = -\exp(-r\omega)$ where $r > 0$ is the coefficient of absolute risk aversion. Reservation wages are assumed to be zero.

The manager's expected net wage, ω and **the shareholder's expected profits**, $E(B)$ write:

$$\omega = E(w) - C(e_1, .., e_n) \tag{2}$$

$$E(B) = E(y) - E(w) \tag{3}$$

where $C(e_1, .., e_n)$ is the manager's cost of efforts and the expected wage $E(w)$ is linear in the observable performance measure:

$$E(w) = \alpha E(y) + \beta \tag{4}$$

with α the variable part ('piece rate') and β the fixed part of the compensation to be determined by the shareholder such that the maximum effort levels are chosen by the manager in equilibrium.

In the LEN multi-task model, **the manager's certainty equivalent** and the **joint surplus (in certainty equivalent)** are given by

$$CE^m = \alpha \sum_{i=1}^{n} e_i + \beta - C(e_1, .., e_n) - \frac{r\alpha^2\sigma^2}{2} \tag{5}$$

$$CE^{js} = \sum_{i=1}^{n} e_i - C(e_1, .., e_n) - \frac{r\alpha^2\sigma^2}{2} \tag{6}$$

where $\frac{r\alpha^2\sigma^2}{2}$ is the risk premium.[10]

[9] The delegation of productive efforts (independently of any CSR dimension) could also be analyzed (for instance in our benchmark case with n tasks), but we restrict our analysis to CSR tasks in order to remain as close as possible to the variables of our database in the econometric analysis.

[10] For a general demonstration of the certainty equivalent see Milgrom and Roberts (1992).

The equilibrium contract is determined by the shareholder by anticipating that the manager's effort levels will be chosen so as to maximize the manager's certainty equivalent. It is thus determined in three steps:
• *Step 1 - Incentive compatible constraint*: α such that $e_i = \arg\max CE^m$, $\forall i = 1..n$
• *Step 2 - Participation constraint*: β such that $CE^m = 0$
• *Step 3 - Optimal contract*: $(e_1, .., e_n) = \arg\max E(B)$

The different CSR tasks may be relative complements (or substitutes) from the manager's perspective, that is in terms of managerial effort cost. We now thus define cost complementarity between the CSR tasks.

3.2 Pairwise Cost Complementarity between the CSR Tasks

A group of CSR tasks is complementary if doing more of any subset of them increases the returns from doing more of any subset of the remaining tasks, in other words when 'the whole is more than the sum of its parts'.

We restrict our analysis to $n = 3$ CSR tasks (in accordance with definition 1) to obtain analytical results in various cases of complementarity and substitutability between the CSR tasks. The complementarity between the different CSR dimensions is defined as follows.

Definition 2. Cost complementarity between CSR practices. *Given the extra-financial ratings, two CSR practices are relative complements when the cost of effort in one CSR task decreases when another CSR task is implemented.*

Relative complementarity between the CSR tasks affects the manager's cost of effort $C(e_1, e_2, e_3)$ as follows. The rating of the extra-financial agency is exogenous and publicly observed before effort decisions are made. Let μ denote the impact of extra-financial ratings on the cost of effort (thereby capturing the degree of cost complementarity) with $0 < \mu < 1$.

The manager's cost of effort then is defined by:

$$C(e_1, e_2, e_3) = \frac{1}{2}.c.\sum_{i=1}^{3} e_i^2 - c.\mu.\phi(e_1, e_2, e_3) \tag{7}$$

where $c > 0$, $0 < \mu < 1$ reflects the degree of pairwise cost complementarity and $\phi(e_1, e_2, e_3)$ captures the cross effects between tasks.

When there are more than two dimensions, an important result from the theory of supermodularity states that a function is supermodular over a subset of its argument if and only if all pairwise components in the subset are complementary. In other words when there are more than two dimensions it suffices to check pairwise complementarities (see Mohnen and Roller (2005), or Topkis (1978)). We thus have the following definition.

Definition 3. Pairwise Cost Complementarity and Supermodularity. *Pairwise cost complementarity between task i and j implies that the cost function is submodular in i and j, $C''_{ij} < 0$, and the joint surplus in certainty equivalent is supermodular in i and j, that is given equations (6) and (7): $(CE^{js})''_{ij} = -C''_{ij} = c.\mu.\phi''_{ij} > 0$.*[11]

Consistently with evaluation methodologies of extra-financial agencies, the CSR ratings μ reflects the relative position of the firm on each CSR dimension with respect to the sectoral average as follows. The ratings are observed by both parties before effort decisions are made and in each business sector, the rating agency identifies the key CSR issues and the firm receives a rating either above or below sectoral average.[12] Hence the firm may be 'pro-active' (above sectoral average) or 'reactive' (below sectoral average) on each CSR task. Indeed, the rating agency decision is treated here as a binary variable that takes the value of 1 if the firm is pro-active in its sector on a given CSR task and 0 otherwise.

If the firm receives a rating above sectoral average on one CSR task only, the degree of cost complementarity is denoted by m_{100}, m_{010} or m_{001}. Similarly, if the firm receives a rating above sectoral average on two CSR tasks, the degree of cost complementarity is denoted by m_{110}, m_{101} and m_{011}. And, if the firm receives a rating above (respectively below) sectoral average on the three CSR tasks, the degree of cost complementarity is denoted by m_{111} and by m_{000} respectively. A rating below sectoral average on all CSR dimensions is normalized to zero. Parameter μ is thus defined over the set M of mutually exclusive values:

$$\mu \in M = \{m_{100}, m_{010}, m_{001}, m_{110}, m_{101}, m_{011}, m_{111}, m_{000}\} \tag{8}$$

with $m_{000} = 0$ and $0 < \mu < 1$ otherwise.

For continuous variables, complementarity implies that the cross-partial derivatives are positive (see definition 3). For discrete choice variables (binary variable equal to 1 if the firm's rating is above sectoral average and 0 otherwise), supermodularity implies 'increasing differences' (see Leiponen (2005) or Topkis (1998)). Supermodularity of the joint surplus in certainty equivalent thus implies the following 6 inequalities (or increasing differences):[13]

$$CE^{js}_{11x} - CE^{js}_{10x} \geq CE^{js}_{01x} - CE^{js}_{001} \tag{9}$$
$$CE^{js}_{1x1} - CE^{js}_{01x} \geq CE^{js}_{1x0} - CE^{js}_{0x0} \tag{10}$$
$$CE^{js}_{x11} - CE^{js}_{x01} \geq CE^{js}_{x10} - CE^{js}_{x00} \tag{11}$$

with $x = \{0, 1\}$.

[11] With $F''_{ij} = \frac{\partial^2 F}{\partial i \partial j}$.

[12] Absolute ratings convey little information as they may signal true engagement if the sectoral average is low on this CSR task or little engagement if the sectoral average on this CSR task is very high. Hence, it is the relative rating with respect to the sectoral average that matters.

[13] By symmetry, with substitutable pairs of CSR tasks, the joint surplus exhibits decreasing differences.

Using equations (6) and (7), we have
$CE^{js} = \sum_{i=1}^{3} e_i - \frac{r\alpha^2\sigma^2}{2} - \frac{1}{2}.c.\sum_{i=1}^{3} e_i^2 + c.\mu.\phi(e_1, e_2, e_3)$.

Substituting for the corresponding values of $\mu \in M$, the previous inequalities write:

$$m_{111} - m_{101} \geq m_{011} - m_{001} \quad \text{and} \quad m_{110} - m_{100} \geq m_{010} \tag{12}$$
$$m_{111} - m_{011} \geq m_{110} - m_{010} \quad \text{and} \quad m_{101} - m_{001} \geq m_{100} \tag{13}$$
$$m_{111} - m_{101} \geq m_{110} - m_{100} \quad \text{and} \quad m_{011} - m_{001} \geq m_{010} \tag{14}$$

where we have used the fact that $m_{000} = 0$.

Among the three pairs (1,2), (2,3) and (1,3), several 'regimes' of pairwise complementarity may be considered. We will analyze the following situations: three independent pairs (benchmark case), one pair of complementary tasks (case i); two pairs of complementary tasks (case ii); one pair of complementary tasks and one pair of substitutable CSR tasks (case iii); and three pairs of complementary tasks (case iv).[14]

These different configurations and the corresponding values of $\phi(e_1, e_2, e_3)$ are summarized as follows.

	pair (1,2)	pair (2,3)	pair (1,3)	$\phi(e_1, e_2, e_3)$
benchmark	independent	independent	independent	0
case i	**complement**	independent	independent	$e_1.e_2$
case ii	**complement**	**complement**	independent	$e_1.e_2 + e_2.e_3$
case iii	**complement**	**substitutable**	**complement**	$e_1.e_2 - e_2.e_3$
case iv	**complement**	**complement**	**complement**	$e_1.e_2 + e_2.e_3 + e_1.e_3$

We now solve the model in each configuration of cost complementarity.

3.3 Equilibrium contracts

- **Benchmark Case: Cost Independence between the CSR Tasks**

When the tasks are independent, the manager's cost of effort is given by:
$C(e_1, e_2, e_3) = \frac{1}{2}.c.\sum_{i=1}^{3} e_i^2$.

The incentive compatible constraint (step 1) writes: $\alpha = \frac{\partial C}{\partial e_i}$ $\forall i = 1..3$. This implies that effort levels are symmetric : $e_i = e^0 \quad \forall i = 1..3$. We thus get: $\alpha = c.e$.

[14]Substitutability between one or two pairs of CSR tasks is symmetric to the case of complementarity between one or two pairs.

The participation constraint (step 2) writes: $\beta = C(e_1, e_2, e_3) - \alpha(\sum_{i=1}^{3} e_i) + \frac{r\alpha^2\sigma^2}{2}$. Given symmetric effort levels, the manager's expected wage thus writes: $E(w) = \frac{ce^2}{2}(3 + rc\sigma^2)$.

The optimal contract (step 3) is then such that $e = \arg\max E(B) = 3e - E(w)$, which leads to:[15]

$$e_1 = e_2 = e_3 = e^0 = \frac{3}{c\,(3 + rc\sigma^2)} \qquad E(w)^0 = E(B)^0 = \frac{9}{2c\,(3 + rc\sigma^2)} \tag{15}$$

• Case i: One Pair of Complementary CSR Tasks

In this case, the cost function writes: $C(e_1, e_2, e_3) = \frac{1}{2}.c.\sum_{i=1}^{3} e_i^2 - c.\mu.e_1e_2$. For $0 < \mu < 1$, the equilibrium contract is then given by:

$$e_1 = e_2 = e^I = \frac{3 - \mu}{c\,[2 + (1-\mu)^2 + rc\sigma^2(1-\mu)^2]} \quad e_3 = (1-\mu)e^I \tag{16}$$

$$E(w)^I = E(B)^I = \frac{(3-\mu)^2}{2c\,[2 + (1-\mu)^2 + rc\sigma^2(1-\mu)^2]} \tag{17}$$

• Case ii: Two Pairs of Complementary CSR Tasks

Here, the cost function writes: $C(e_1, e_2, e_3) = \frac{1}{2}.c.\sum_{i=1}^{3} e_i^2 - c.\mu.(e_1e_2 + e_2e_3)$. Solving the model yields for $0 < \mu < 1/\sqrt{2}$:

$$e_1 = e_3 = e^{II} = \frac{(3+4\mu)(1+\mu)}{c\,[3 + 4\mu - 2\mu^2 + rc\sigma^2(1-2\mu^2)^2]} \quad e_2 = \frac{1+2\mu}{1+\mu}e^{II} \tag{18}$$

$$E(w)^{II} = E(B)^{II} = \frac{(3+4\mu)^2}{2c\,[3 + 4\mu - 2\mu^2 + rc\sigma^2(1-2\mu^2)^2]} \tag{19}$$

[15] These results can be generalized to n independent task, the optimal contract is then characterized by $e^0 = \frac{n}{c(n+rc\sigma^2)}$ $E(w)^0 = E(B)^0 = \frac{n^2}{2c(n+rc\sigma^2)}$.

• **Case iii: One Pair of Complementary CSR Tasks and One Pair of Substitutable CSR Tasks**

In this case, the cost function writes: $C(e_1, e_2, e_3) = \frac{1}{2}.c.\sum_{i=1}^{3} e_i^2 - c.\mu.(e_1e_2 - e_2e_3)$. Solving the model implies for $0 < \mu < 1/\sqrt{2}$:

$$e_3 = e^{III} = \frac{(3-4\mu^2)(1-\mu-2\mu^2)}{c\left[1+2(1-2\mu^2)^2-2\mu^2+rc\sigma^2(1-2\mu^2)^2\right]} \tag{20}$$

$$e_1 = \frac{1+\mu-2\mu^2}{1-\mu-2\mu^2}e^{III} \quad e_2 = \frac{e^{III}}{1-\mu-2\mu^2} \tag{21}$$

$$E(w)^{III} = E(B)^{III} = \frac{(3-4\mu^2)^2}{2c\left[1+2(1-2\mu^2)^2-2\mu^2+rc\sigma^2(1-2\mu^2)^2\right]} \tag{22}$$

• **Case iv: Three Pairs of Complementary CSR Tasks**

Here, the cost function writes: $C(e_1, e_2, e_3) = \frac{1}{2}.c.\sum_{i=1}^{3} e_i^2 - c.\mu(e_1e_2 + e_2e_3 + e_1e_3)$. For $0 < \mu < 1/2$ the equilibrium contract is:

$$e_1 = e_2 = e_3 = e^{IV} = \frac{3}{c(1-2\mu)\left[3+rc\sigma^2(1-2\mu)\right]} \tag{23}$$

$$E(W)^{IV} = E(B)^{IV} = \frac{9}{2c(1-2\mu)\left[3+rc\sigma^2(1-2\mu)\right]} \tag{24}$$

3.4 Comparative Statics

Some comparative statics exercises on each configuration of cost complementarity leads to the following results.

Result 1. *CSR ratings have a positive impact μ on managerial CSR effort and expected profits when:*
⋆ *the three CSR tasks are pairwise complementary and* $0 < \mu < 1/2$,
⋆ *two pairs of CSR tasks are complementary and* $0 < \mu < 1/\sqrt{2}$.

Proof. See appendix 7.1. ■

Result 1 shows that when the CSR practices are pairwise relative complements, the impact of the CSR ratings on optimal efforts and profits is positive. It is consistent with empirical studies highlighting a positive impact of CSR on firm performance (see e.g. Konar and Cohen (2001), Richard et al. (2007) or Baron et al. (2008)).

However, there is no consensus in the empirical literature on this issue and this may be explained by the complex interactions (complementarity and substitutability) between the different components of a firm's CSR policy.

Result 2. *CSR ratings have an ambiguous impact μ on managerial CSR effort and expected profits when:*
$\star$ *two CSR task are pairwise complementary and* $0 < \mu < 1$*,*
$\star$ *two CSR tasks are complementary and two others are substitutable and* $0 < \mu < 1/\sqrt{2}$*.*

Proof. See appendix 7.2. ■

Result 2 shows that when we take into account both pairwise complementarity and pairwise substitutability between the CSR tasks, the impact of extra-financial ratings is no longer monotonous, which is consistent with the absence of consensus in the empirical literature on this issue. We now explicit the testable predictions of our model.

3.5 Testable Predictions of the Model

Results 1 and 2 state that CSR ratings have a positive impact on firm performance when two or three pairs of CSR tasks are complementary. Otherwise, when only one pair is complementary and/or one pair is substitutable, CSR ratings have an ambiguous impact on firm performance. We thus have the following testable prediction.

Prediction 1. *The impact of CSR ratings on firm performance depends on the complementarity or substitutability between the different CSR tasks.*

To determine which CSR tasks are pairwise complements or substitutes, that is which pair implies super (or sub) modularity of firm performance, we have seen that it is sufficient to test for increasing (or decreasing) differences of firm performance. We thus have the following testable prediction.

Prediction 2. *Two CSR tasks are pairwise complementary (resp. substitutable) when firm performance exhibits increasing (resp. decreasing) differences in the impact of CSR ratings.*

We now turn to the empirical analysis.

4 Data and Variables

Our theoretical predictions are tested using a matched CSR-firm performance database panel. The CSR variables come from the Vigeo database, the leading European CSR rating agency. The firm performance variables come from the Orbis dataset (Bureau Van Dijk), a comprehensive database from the companies' standardized annual accounts, consolidated and unconsolidated, together with their financial profile.

4.1 Firms' Characteristics and Performance

Variables measuring firms' characteristics and performance are extracted from the Orbis database which contains information combined from nearly 100 sources (Datamonitor, Zephyr, Coface etc.) filtered into various standard report formats. The dataset has up to 25 data sections and 10 years of history, including detailed information from the companies' standardized[16] annual accounts, consolidated and unconsolidated, together with financial profile (balance sheet, P&L account, financial ratios), activities and ownership (cash flow, total assets, intangible assets valuation etc.), profitability ratios (profit margin, solvency ratio etc.) and operational and structure ratios.

We use two types of variables from the Orbis dataset. The first type of variables represent the firms' characteristics (control variables) in terms of operational and financial structure. To explain firm performance, the usual control variables are considered (see e.g. Baron et al., 2008; Waddock and Graves, 1997): firm size (log sales); assets (on a log scale); and debt ratio. To control for the sensitivity to stock market variations, we introduce a dummy variable identifying firms listed at the Dow Jones STOXX600 index. Moreover, to control for differences between countries and industries, we include country and industry dummies; and to control for macroeconomic variations and business cycle fluctuations we introduce yearly dummies (year fixed effects). Finally, we also introduce two important variables (often omitted in the literature due to the lack of data). The first one is a Research and Development intensity indicator measured by the R&D expenses divided by the total sales. To identify the absence of reported R&D expenditures in the annual accounts, a dummy variable with a value of 1 is included if R&D expenses are not reported by the firms. The second variable, following Elsayed and Paton (2005), is the ratio of total intangible assets to total sales in order to capture a proxy for advertising.

The second set of variables from the Orbis database characterizes firm performance. Traditionally, firm performance is measured by accounting or by market-based indicators. Both types of measures represent different perspectives on the value of firm performance[17]. Accounting measures such as return on assets, return on equity or

[16] Orbis information is standardized given the differences in accounting practices across countries.

[17] In a companion paper, we explicitly compare the links between firms' social and or environmental policies and both types firm performance measures (see Cavaco and Crifo, 2010b).

return on sales, capture the historical aspects of firm performance and are therefore backward-looking (Mcguire et al., 1986). Such variables may however be subject to bias from managerial manipulation and differences in accounting procedures across countries (Branch and Cole, 1983). Therefore we chose to rather rely on a market performance measure, the Tobin's q, which is a measure of return based on the stock market (market value of a company's stock compared to the value of a company's equity book value). The Tobin's q represents the investors' evaluation of the ability of a firm to generate future economic earnings and is therefore forward-looking. This performance indicator thus seems more appropriate to capture the expected future impact of CSR on performance (Hillman and Keim, 2001). Note that the Tobin's q may be sensitive to variations that are independent of the operations and social activities of firms like macroeconomic shocks and political issues or to industry-specific factors such as rising or falling prices due to shifts in industry demand or restrictions on supply, as in the case of oil or other raw materials. Introducing year and industry dummies therefore allows capturing such factors.

The definition and descriptive statistics of the variables describing firm characteristics and performance are reported in Tables 1a and 1b respectively.

[Insert Tables 1a and 1b]

4.2 Measuring Corporate Social Responsibility

To measure corporate social responsibility, we rely on the Vigeo database. Vigeo is the leading European extra-financial rating agency, it evaluates the CSR performance and risk factors on Environmental, Social and Governance (ESG) criteria of European firms listed on the DJ STOXX 600 and MSCI World indexes. It supplies this information to investors and asset managers notably.[18] Vigeo provided detailed data on 595 European firms from 1998 to 2007.

4.2.1 Vigeo's Rating Methodology

Vigeo measures companies' CSR performance on 6 broad domains: Human Rights, Environment, Human Resources, Business Behavior, Corporate Governance and Community Involvement. All of the 6 domains are not investigated for the whole sample by Vigeo because before companies are rated, an analysis is done to identify the key CSR issues within the business sector. This determines which criteria in each of the 6 domains will be activated in each sector. A 'weight' is then assigned to each criterion on a scale from 1 to 3, based on the nature of the impact of the CSR issue on

[18] A comparable, but more comprehensive, database is the KLD database covering firms listed on the S&P 500, Domini 400 Social Index or Russell 1000 and 3000 indexes used for instance by Chatterji et al. (2007) or Baron et al. (2008). Vigeo or KLD extra-financial databases do not report how much each firm spends on CSR activities. We are not aware of available CSR expenditure data.

the sector's stakeholders; the exposure of stakeholders to that impact and the risks (legal, operational, etc.) run by companies in the sector that do not manage this impact adequately. Once the evaluation criteria have been customized for the sector, Vigeo's analysis focuses on how each company addresses each criterion in terms of Leadership, Implementation, and Results through a series of detailed questions:

- Leadership: visibility (types of policies in place), content (content of these policies) and ownership (responsibility for these policies).
- Implementation: means and resources (programs and tools in place), scope (aspects addresses by these tools) and coverage (parts of the company covered by these tools).
- Results: indicators (quantitative data) and controversies (stakeholder information).

Each of these questions is scored on a scale from 0 to 100, representing the level of firm's CSR engagement and management of associated risks. A score of 0 shows little evidence of commitment (poor to very poor guarantee of risk management), 30 means an initiated commitment (poor to moderate guarantee of risk management), 65 means a consolidated commitment (reasonable guarantee of risk management) and a score of 100 shows an advanced commitment (social responsibility objectives actively promoted). Points given for each question are then consolidated through a system of weighted averages to give an overall score for each criterion and each domain (out of 100).

In line with definition 1, we restrict our analysis to three CSR areas which appear to be more complementary: environment, human resources and business behavior towards customers and suppliers. This restriction is motivated by two main reasons. On the one hand, as explained above, not all criteria in each of the 6 CSR areas are activated for each sector and this leads to many missing data when taking into account all 6 CSR areas. In particular, the human rights and community involvement criterion is not specified for all firms. On the other hand, corporate governance ratings are very stable across time and sectors. This characteristics may be explained by the fact that this dimension of CSR is most likely determined between shareholders and boards of directors, and is traded-off by managers to a much lesser extent than the other components of CSR. We therefore do not rely on this criterion in our empirical analysis.

Overall, average scores exhibit differences across countries and sectors, as shown in Tables 2 and 3.

[Insert Table 2]

We see from table 2 that the best performances in terms of human resources are observed in France, Norway, the Netherlands and Germany. The best performances

on environmental issues are observed in Norway, Germany and the United Kingdom. Finally, the United Kingdom, the Netherlands, Finland and Norway report the highest scores on business behavior (towards customers and suppliers). For both social and environmental domains, Greece and Ireland report the lowest scores. It is thus worth controlling for countries' differences as CSR efforts are likely to depend on the legal system.

Furthermore, clear differences in performances and CSR efforts may exist across industries. Table 3 reports the average industry CSR scores.

[Insert Table 3]

From table 3 we see that the best performing sectors in terms of CSR are also sectors which have to face a negative image in the public opinion regarding environmental or social responsibility such as the automobile, transport or energy industries. There are also differences between industries: least performing sectors on environmental and social (human resources) issues are the media and hotel industries.

The descriptive analysis highlights the importance of controlling for sectors when estimating the relationship between firm performance and CSR. As pointed out by Benabou and Tirole (2010), it is worth taking into account relative performance within the industry. In fact, the score allocated by Vigeo to a company in each domain is compared against the scores of all other companies in the sector. This score leads to one of the 5 different ratings, depending on the distribution of scores within the sector, on that domain. The company may be ranked as: the least performing (–), below average performer (-), average performer (=), active performer (+) or leading performer in the sector (++). This sector related rating method is thus not based on ranking but on how far scores deviate from the average.

4.2.2 From CSR Ratings to CSR Tasks

To measure CSR tasks, given this rating methodology, requires codifying a measure applicable to different firms across sectors and comparable across different CSR areas. Since the evaluation process distinguishes between firms receiving ratings above or below sectoral average, we rely on the following definition.[19].

Definition 4. *The CSR task is a dummy variable that takes the value of 1 (resp.0) the firm is ranked above (resp. below) the sectoral average on the corresponding CSR dimension.*

[19]An alternative strategy would be to keep the continuous CSR scores and rely on sectoral dummies to capture the industry specific effect. This strategy is adopted in a companion paper (see Cavaco and Crifo, 2010a). The problem with relying on continuous CSR scores is that it does not allow accounting for the specific combinations between all CSR practices simultaneously and it suffers from collinearity problems because the continuous scores are correlated (see table 4d). Here, we therefore rely on ranked CSR efforts in order to account for the company's relative ranking in the sector.

The definition and descriptive statistics of the variables measuring CSR tasks are reported in Tables 4a, 4b and 4c respectively.

[Insert Tables 4a, 4b and 4c]

From table 4c, we see that the percentage of firms with CSR scores above the sectoral average is decreasing. This may reflect both an increasing competition between firms and a stricter international regulation imposing tighter constraints and/or stronger market contestability on these dimensions of CSR.

In addition, we report in Table 4d an analysis of the pair-wise correlation between the three CSR variables.

[Insert Table 4d]

The estimation of unconditional correlations (e.g. Spearman rank correlation) between the three CSR variables shows that business behavior (towards customers and suppliers), environmental and social tasks are highly positively correlated. Since correlations might be induced by unobserved factors, we cannot conclude on a true existence of complementarities from these types of results but simply that this issue has to be explicitly investigated. Besides, the high degree of intercorrelation among CSR variables indicates that empirical models estimating the impact of any one CSR policy on firm performance will yield biased coefficients due to the omission of the other CSR variables. One possible solution to this problem would be to enter the entire set of potentially important CSR variables into the firm performance equation. However, as pointed out by Ichniowski et al. (1997), this approach is confounded by the severe collinearity among CSR practices, making any one coefficient uninterpretable, and would not directly test whether combinations of CSR practices are the critical determinants of firm performance. In order to examine the effects of highly correlated variables sets, one should simultaneously estimate the effects of all the pair-wise interactions among the practices. Once more, a complete set of interaction terms still would be confounded by collinearity among practices, so finally we should identify common clusters of CSR practices.

In order to identify clusters of CSR practices, we construct exclusive categories to represent the CSR tasks. Table 5a displays the definition for the different CSR states. In particular, we define 8 dummy variables by following the convention of binary algebra. They are equal to one when the CSR task receives a rating above sectoral average and zero otherwise. Descriptive statistics for the CSR states are reported in Table 5b.

[Insert Table 5a and 5b]

From Table 5b, we see that the most frequent state is the extreme one - best performances on all CSR practices (45%), whereas the other states are uniformly distributed.

Finally, in order to avoid the sample selection issue, we do not require a balanced panel. Thus, the number of firms in our sample differs year to year and the estimation strategy uses as many observations as available. Moreover, in order to introduce the lagged value of the dependent variable (see our estimation strategy below), we have to observe firms over at least two consecutive years. We thus exclude firms that do not provide complete information. Our final unbalanced panel sample comprises 1 094 observations (around 300 firms per year) in 15 countries over the period 2002-2007.

5 Empirical Strategy and Results

Our econometric strategy is twofold: first, we estimate the determinants of firm performance in order to obtain consistent estimates and second, we identify the relative complementarity or substitutability between the different CSR variables in the CSR-performance relationship.

5.1 Econometric Model of the Determinants of Firm Performance

A plausible model of the CSR-firm performance relationship should exploit the panel structure of our data and, thus take into account the dynamics structure, whereby past performance explains current performance. The main issue is that when we investigate the relationship between CSR and firm performance, current firm performance is likely to be correlated with both the observable and unobservable factors (i.e. observable and unobservable heterogeneity) that also determine CSR strategies. Moreover, causality may run in both directions, that is from CSR to firm performance and from performance to CSR.

We thus estimate the relationship between firm performance, labelled Π_{it} (Tobin's q), its lagged value, Π_{it-1}, the CSR states dummies, CSR_{it} and a set of control variables, labelled X_{it}, according to the following equation:

$$\Pi_i t = \beta_1 \Pi_{it-1} + \beta_2 CSR_{it} + \beta_3 X_{it} + \beta_4 \lambda_i + \beta_5 \gamma_i + \mu_i + \delta_t + \varepsilon_{it} \tag{25}$$

where i refers to individual firm and t to time dimension, μ_{it} are unobserved firm-specific fixed effects, δ_t are time dummies and ε_{it} is the error term. X_{it} are potentially predetermined firm-level time-variant control variables, λ_i are time-invariant exogenous industry level control variables (dummies) and γ_i are country dummies.

To obtain consistent and unbiased results, we estimate the relationship between CSR investments and firm performance using the dynamic Generalised Method of Moments (GMM) estimator, called system GMM (see e.g. Arellano and Bond, 1991, and Blundell and Bond, 1998)[20]. The estimation procedure exploits the dynamic endogeneity of our variables. In particular, the system GMM estimator extends the GMM in differences by estimating a system of first-difference equations and level equations with a wider set of instruments.[21]

The system GMM estimator thus allows to obtain consistent estimates by controlling for unobserved heterogeneity and fixed effects, endogeneity and time-invariant variables. Two conditions are required for estimators to be consistent. First, the error term has to exhibit no serial correlation. We rely on the autocorrelation test on the residuals proposed by Arellano and Bond (1991) to determine whether this condition is satisfied. Second, the validity of the instruments must be guaranteed. We rely on a test of over-identifying restrictions, the Hansen test, to check the overall validity of our instruments. In particular, in the level equations, the instruments must be uncorrelated with the fixed effects. Moreover, this method flexibly accommodates unbalanced panels.

5.2 Testing for Complementarity between CSR Practices

Several alternative empirical testing procedures have been derived to formally examine complementarity among business practices (see Athey and Stern, 1998 for an overview). Here, we follow the 'productivity approach' which has been implemented in various specifications in the innovation literature with a precise examination of multiple complementarities (see e.g. Mohnen and Roller, 2005; Leiponen, 2005; Belderbos et al., 2006). This approach relies on a direct test of supermodularity (see definition 3). As pointed out by Mohnen and Roller (2005), the individual significance and signs of the coefficients do not directly reveal whether practices are complementary or substitutable for two reasons. First, complementarity involves testing linear restrictions on several coefficients. Second, complementarity requires testing the joint distribution of several of these linear restrictions. For both reasons, it is possible that all coefficients be statistically insignificant, even though the joint hypothesis for complementarity is accepted.

In order to empirically identify complementarities between CSR variables, we follow Mohnen and Roller (2005) and first obtain consistent and efficient estimates of the

[20]The GMM estimator was first introduced by Holz-Eakin et al.(1988) and Arellano and Bond (1991) and then further developed both in Arellano and Bover (1995) and Blundell and Bond (1998)

[21]Regarding the system GMM estimator, the only available instruments are "internal", based on lagged values of the instrumented variables. In the first-difference equations, the lagged values of the variables are used as instruments and in the level equations, differences are used as instruments.

CSR states coefficients (see Table 6) and second, using the methods developed by Kodde and Palm (1986) we test explicitly for super and sub modularity between CSR pairwise states (see Table 7).

More precisely, given the definition of the CSR state dummies in Table 5a, we write the inequality constraints for supermodularity as a set of restrictions on the coefficients on the state variables. We need to test jointly for the set of 6 inequality constraints on the CSR states coefficients. As pointed out by Mohnen and Roller (2005), given that pairwise complementarity between any subset of CSR practices implies supermodularity over the whole subset, we just need to test each CSR pair separately. Moreover, we can test both for supermodularity and submodularity, since CSR practices can also be substitutes. In the case of submodularity, the inequalities would have the opposite signs[22].

In line with equations (13), (14) and (14), the inequality constraints on the coefficients supporting supermodularity (that is complementarity) write (using the estimates β_2 in equation (25)):

$$\text{(HR,ENV) supermodular: } \beta_{111} - \beta_{101} \geq \beta_{011} - \beta_{001} \quad \text{and} \quad \beta_{110} - \beta_{100} \geq \beta_{010} \tag{26}$$

$$\text{(HR,CS) supermodular: } \beta_{111} - \beta_{011} \geq \beta_{110} - \beta_{010} \quad \text{and} \quad \beta_{101} - \beta_{001} \geq \beta_{100} \tag{27}$$

$$\text{(ENV,CS) supermodular: } \beta_{111} - \beta_{101} \geq \beta_{110} - \beta_{100} \quad \text{and} \quad \beta_{011} - \beta_{001} \geq \beta_{010} \tag{28}$$

where we have used the fact that $\beta_{000} = 0$.

The joint test for the set of 6 inequality constraints (restrictions) on the CSR states coefficients characterizing pairwise complementarity is such that imposing each pair of restrictions under the null hypothesis, implies that the inequalities must be satisfied simultaneously while under the alternative there are no restrictions. Testing for pairwise complementarity under the null hypothesis, and considering that the test for supermodularity is a one-sided test of a given pair of inequality, we thus compute a distance measure and compare it with lower and upper bound critical values for the distance test or Wald test. Values of the Wald test below the lower bound critical value imply that the null hypothesis is accepted. Values above the upper bound critical value yield a rejection of the null hypothesis. Values in between the two bounds imply that the test is inconclusive.

5.3 Results

Table 6 displays the regression analysis for the system GMM estimation[23]. The set of instruments is composed of the dependent variable, the CSR states dummies and

[22]The tests for submodularity and supermodularity are joint, one-sided Wald tests of the constraints.

[23]Estimations were carried out using the Stata module Xtabond2 developed by D. Roodman (2006).

the control variables, all in lag two. We use robust standard errors and valid the two previously presented standard tests on misspecification. The Arellano and Bond test on autocorrelation supports the overall validity of the model by providing evidence of first order autocorrelation (AR1) and the absence of second order autocorrelation (AR2) while the Hansen test supports the consistency of the GMM instruments. Thus, our estimation controls properly for potential correlation between unobserved factors and the regressors, which is a critical issue in the empirical literature on complementarities.

[Insert Table 6]

The positive and significant coefficient of the lagged dependent variable confirms that firm performance is persistent. In fact, a firm performance depends substantially on its own past realizations. Regarding the control variables determining the firm performance, we find that the majority of the estimates have the expected signs. A firm performance is positively related to the debt-to-asset ratio. This result can highlight that there is a positive relation between the debt ratio and the size of the firms. Table 6 also illustrates that both sales and Research and Development intensity have a positive impact on firm performance.

We then test for the sign of the relationship between CSR combinations and firm performance. In line with the literature, the sign may imply negative, neutral or positive links between firm performance and CSR practices. A negative sign implies that socially responsible firms have a competitive disadvantage because they incur costs that reduce profits, while these costs could be avoided or borne by individuals or the government. A positive sign implies that the actual costs of CSR practices adoption are covered by the benefits since socially responsible companies would thus prove a better risk management of negative events (fines, costly lawsuits etc.).

Regarding the CSR variables, we see that a high performance (ranking above average) on human resources (HR) has a positive impact on firm performance (coefficient on state100 positive and significant). However, the coefficients on the different states convey little information and the significance and signs do not reveal whehter they are complementary or substitutable.

To formally test for complementarity (i.e. supermodularity) between the CSR variables, we must explicitly test the 6 inequality restrictions on the coefficients. Table 7 presents the results of the joint tests for these inequality restrictions.

[Insert Table 7]

Table 7 should be interpreted as follows. If the test value is below 0.455, the null hypothesis of supermodularity (submodularity) is accepted, and if the test value is above 2.090, the null hypothesis is rejected (at $\alpha = 0.25$). For test values between the two critical values, the test is inconclusive. Testing simultaneously for

both supermodularity and submodularity allows distinguishing between weak and strict super and sub modularity. In fact, when supermodularity can be accepted and submodularity rejected simultaneously, there is evidence for strict supermodularity. When supermodularity can be accepted but the submodularity test is inconclusive, the evidence for strict supermodularity is weaker. Finally, when both supermodularity and submodularity can be accepted simultaneously, strict supermodularity is rejected.

We therefore have the following results:

- for human resources (HR) and environment (ENV) the test is inconclusive;
- for human resources (HR) and business behavior towards customers and suppliers (CS) the null hypothesis of supermodularity is accepted and the null hypothesis of submodularity is rejected (strong supermodularity);
- for environment (ENV) and business behavior towards customers and suppliers (CS): the supermodularity test is inconclusive and the null hypothesis of submodularity is accepted (weak submodularity);

Supermodularity implies that one should not observe any combination of practices. Here, we show that one pair of CSR task is substitutable (submodular): ENV & CS and one pair of CSR task is complementary (supermodular): HR & CS.

In other words, two types of strategies positively affect firm performance. On one hand, CSR efforts should be simultaneously high (ranking above average in the sector) on human resources and business behaviors (customers and suppliers). On another hand, there is a trade-off between environment and business behaviors towards customers and suppliers: CSR efforts which are simultaneously high on each of these four pairs are not leading to superior performance, it is rather a combination between low and high values (ranking above and below average in the sector) within each of these criteria that positively affect firm performance.

Our results provide an original contribution to the existing literature as we show that the nature of complementarity or substitutability between different CSR practices matters in the CSR-firm performance relationship. Some combinations are rather complementary inputs of firm performance (human resources and business behaviors) while others are rather substitutable inputs of firm performance (environment and business behaviors). More generally, since our measure of firm performance is based on a market indicator, the Tobin's q, our results may be interpreted as the residual market reward for such combinations of CSR practices (given all the control variables that usually explain such performance) that may be compared to a type of "investors' premium" for specific CSR combinations.

These results suggest that investors are likely to value two types of business models in terms of CSR strategies. The first 'model' corresponds to companies ranked as

leading (above average) performers in the sector on both the human resources and the business behaviors domains. For instance, over the past decade, the Ford Motor Company has developed an innovative project - the Supply Chain Sustainability group - in order to promote its CSR priorities in the supply chain (business behaviors component), along with a Code of Basic Working Conditions covering workplace issues such as compensation, freedom of association and collective bargaining, harassment and discrimination, health and safety, and work hours (human resources component).[24] The second 'model' corresponds to companies ranked as leading (above average) performers in the sector on either the environment or the business behaviors domain. For instance, the Wal-mart group is developing an ambitious plan to boost energy efficiency, cut down on waste and reduce greenhouse gases tied to global warming (environmental component), but remains highly criticized (by NGOs notably) for its business practices and extensive foreign product sourcing, treatment of employees and product suppliers (business behaviors component). [25]

6 Conclusion

This article proposes a theoretical and empirical analysis of the interactions between firm CSR practices and performance, and explicitly examine the relative complementarity between environmental, social and business behaviors issues. Our model shows that the impact of CSR ratings on firm performance depends on the degree of complementarity between the different CSR tasks. Extra-financial ratings have a positive impact on CSR efforts when at least two pairs of CSR tasks are complementary. When only one pair of CSR tasks is complementary (and possibly another one is substitutable) then CSR ratings have an ambiguous impact on CSR efforts and firm performance.

Our empirical analysis tests the main predictions of this model on a matched CSR-firm performance dataset panel of European listed firms over the 2002-2007 period. Testing explictly for complementarity and substitutability between the CSR variables, we identify which pair is more likely leading to an "investors' premium" in the form of a higher Tobin's q. From this perspective, human resources and business behaviors appear as relatively complementary while business behaviors and environmental efforts appear as relatively substitutable.

[24]For further details see the case study by Malte Dold (2009). "The Ford approach towards human rights and business integration" downloadable from the website *http : //www.unglobalcompact.org*

[25]Wal-Mart has already achieved a 60 percent increase in fleet efficiency since 2005 and aims at reducing greenhouse gases at existing store, club and distribution center base around the world by 20 percent by 2012 (see Wal-Mart's sustainability report downloadable from the website *http : //walmartstores.com/sustainability/*). For further details on Wal-Mart's business policies see the case study by Robert Lussier (2008). Management Fundamentals: Concepts, Applications, Skill Development. South-Western College Pub, p.77-78.

7 Appendix

7.1 Proof of result 1

In case (iv), efforts at task 1, 2 and 3 are equal to $e^{IV} = \frac{3}{c(1-2\mu)[3+rc\sigma^2(1-2\mu)]}$ and expected profits write $E(B)^{IV} = \frac{9}{2c(1-2\mu)[3+rc\sigma^2(1-2\mu)]} = \frac{3}{2}e^{IV}$.

Thus:

$$\frac{\partial e^{IV}}{\partial \mu} = \frac{-3\big(-2\big[3+rc\sigma^2(1-2\mu)\big]-2rc\sigma^2(1-2\mu)\big)}{c(1-2\mu)^2[3+rc\sigma^2(1-2\mu)]^2} > 0$$

and: $\frac{\partial E(B)^{IV}}{\partial \mu} = \frac{3}{2}\frac{\partial e^{IV}}{\partial \mu} > 0.$

Hence, when $0 < \mu < 1/2$, we have $\frac{\partial e^{IV}}{\partial \mu} > 0$ and $\frac{\partial E(B)^{IV}}{\partial \mu} > 0$.

In case (ii), efforts at task 1 and 3 are equal to $e^{II} = \frac{(3+4\mu)(1+\mu)}{c[3+4\mu-2\mu^2+rc\sigma^2(1-2\mu^2)^2]}$, and effort at task 2 write: $\frac{1+2\mu}{1+\mu}e^{II}$.

Thus:

$$\frac{\partial e^{II}}{\partial \mu} = \frac{4(1+\mu)(3\mu+2\mu^2+rc\sigma^2(1-2\mu^2)^2)+(3+4\mu)(3+4\mu-2\mu^2+rc\sigma^2(1-2\mu^2)^2(1+8\mu+8\mu^2)}{c[3+4\mu-2\mu^2+rc\sigma^2(1-2\mu^2)^2]^2} > 0$$

and: $\frac{\partial\left(\frac{1+2\mu}{1+\mu}e^{II}\right)}{\partial \mu} = \frac{\partial e^{II}}{\partial \mu}\frac{1+2\mu}{1+\mu} + e^{II}\frac{2\mu}{(1+\mu)^2} > 0$

Moreover: $E(B)^{II} = \frac{(3+4\mu)^2}{2c[3+4\mu-2\mu^2+rc\sigma^2(1-2\mu^2)^2]} = \frac{e^{II}}{2}\frac{3+4\mu}{1+\mu}$.

Thus: $\frac{\partial E(B)^{II}}{\partial \mu} = \frac{e^{II}}{2(1+\mu)^2} + \frac{\partial e^{II}}{\partial \mu}\frac{3+4\mu}{1+\mu} > 0.$

Hence, when $0 < \mu < 1/\sqrt{2}$, we have $\frac{\partial e^{II}}{\partial \mu} > 0$, $\frac{\partial\left(\frac{1+2\mu}{1+\mu}e^{II}\right)}{\partial \mu} > 0$ and $\frac{\partial E(B)^{II}}{\partial \mu} > 0$.

7.2 Proof of result 2

In case (i), efforts at task 1 and 2 write $e^I = \frac{3-\mu}{c[2+(1-\mu)^2+rc\sigma^2(1-\mu)^2]}$ and effort at task 3 is equal to $(1-\mu)e^I$

Thus:

$$\frac{\partial e^I}{\partial \mu} = \frac{-2-(1-\mu)^2-rc\sigma^2(1-\mu)^2+2(1-\mu)(3-\mu)(1+rc\sigma^2)}{c[2+(1-\mu)^2+rc\sigma^2(1-\mu)^2]^2} >< 0$$

Moreover: $E(B)^I = \frac{(3-\mu)^2}{2c[2+(1-\mu)^2+rc\sigma^2(1-\mu)^2]} = \frac{(3-\mu)e^I}{2}$

Thus: $\frac{\partial E(B)^I}{\partial \mu} = -\frac{e^I}{2} + \frac{(3-\mu)}{2}\frac{\partial e^I}{\partial \mu} >< 0$

Hence, when $0 < \mu < 1$, the sign of $\frac{\partial e^I}{\partial \mu}$, $\frac{\partial\big((1-\mu)e^I\big)}{\partial \mu}$ and $\frac{\partial E(B)^I}{\partial \mu}$ is indeterminate.

In case (iii), effort at task 3 writes $e^{III} = \frac{(3-4\mu^2)(1-\mu-2\mu^2)}{c[1+2(1-2\mu^2)^2-2\mu^2+rc\sigma^2(1-2\mu^2)^2]}$; effort at task 2 writes $\frac{e^{III}}{1-\mu-2\mu^2}$ and effort at task 1 is equal to $\frac{1+\mu-2\mu^2}{1-\mu-2\mu^2}e^{III}$

Thus:

$$\frac{\partial e^{III}}{\partial \mu} = \frac{1}{c[1+2(1-2\mu^2)^2-2\mu^2+rc\sigma^2(1-2\mu^2)^2]^2} \times$$
$$-\left[8\mu(1-\mu-2\mu^2)+(1+4\mu)(3-4\mu^2)\right]\left[1+2(1-2\mu^2)^2-2\mu^2+rc\sigma^2(1-2\mu^2)^2\right]$$
$$+2\left[(3-4\mu^2)(1-\mu-2\mu^2)\right]\left[-(1-4\mu)(1-\mu-2\mu^2)+(1+\mu-2\mu^2)(1+4\mu)-4\mu(1-2\mu^2)rc\sigma^2\right]$$
$$>< 0$$

Hence, when $0 < \mu < 1/\sqrt{2}$, the sign of $\frac{\partial e^{III}}{\partial \mu}$, $\frac{\partial\left(\frac{1+\mu-2\mu^2}{1-\mu-2\mu^2}e^{III}\right)}{\partial \mu}$ and $\frac{\partial\left(\frac{e^{III}}{1-\mu-2\mu^2}\right)}{\partial \mu}$ is indeterminate.

Moreover:$E(B)^{III} = \frac{(3-4\mu^2)^2}{2c[1+2(1-2\mu^2)^2-2\mu^2+rc\sigma^2(1-2\mu^2)^2]} = \frac{e^{III}(3-4\mu^2)}{2(1-\mu-2\mu^2)}$

Thus: $\frac{\partial E(B)^{III}}{\partial \mu} = \frac{3-4\mu^2}{2(1-\mu-2\mu^2)}\frac{\partial e^{III}}{\partial \mu} + \frac{e^{III}}{2}\frac{-8\mu(1-\mu-2\mu^2)+(1+4\mu)(3-4\mu^2)}{(1-\mu-2\mu^2)^2} >< 0$

Hence, when $0 < \mu < 1/\sqrt{2}$, the sign of $\frac{\partial E(B)^{III}}{\partial \mu}$ is indeterminate.

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Table 1a: Variables Definition: Firms Characteristics and Performance

Variable	Definition
Tobinq	(Market value of common equity + preferred stock + total debt)/Total assets
Ln_Sales	Natural log of firm's annual net sales
Ln_Assets	Natural log of firm' annual total assets
Debt_ratio	Long term debt divided by total assets
RD_ratio	Research and Development expenses divided by total sales
RD_dummy	Dummy variable = 1 if firms do not have reported R&D expenses
DJSTOXX600 dummy	Dummy variable = 1 if firms are listed in the DJSTOXX600 index
Advertising_ratio	Total intangible assets divided by total sales

Table 1b: Descriptive Statistics: Firms Characteristics and Performance

Variable	Mean	SD	Min	Max
Tobinq	1.28	1.17	0.11	11.26
Ln_Sales	15.64	1.36	11.64	19.55
Ln_Assets	15.98	1.33	11.97	19.45
Debt_ratio	0.20	0.14	0	1.13
RD_ratio	0.02	0.05	0	0.72
RD_dummy	0.58	0.49	0	1
DJSTOXX600 dummy	0.86	0.35	0	1
Advertising_ratio	0.26	0.27	0	1.47

Table 2. CSR Average Scores per Country

Country	HR	ENV	C_S
Belgium	33	36	26
Denmark	33	35	35
Finland	42	37	38
France	43	35	40
Germany	42	40	40
Greece	19	15	21
Ireland	17	14	25
Italy	33	30	34
Norway	44	43	39
Portugal	37	37	33
Spain	35	35	31
Sweden	33	38	41
Switzerland	36	37	40
Netherlands	42	37	43
United Kingdom	37	41	42

Table 3. CSR Average Scores per Sector

Sector	HR	ENV	C_S
Trade	28	29	40
Consumption	28	25	37
Construction	32	34	34
Energy	43	43	40
Equipment	28	20	38
Finance	42	35	45
Hotel	23	19	35
Agricultural and Food	28	27	40
Intermediary	39	39	40
ITC	31	24	37
Media	24	21	33
Telecom	42	38	40
Transport	35	40	40

Table 4a: Definition of CSR Variables

Variable	Definition
HR_dummy	Dummy variable = 1 if firms have a human resources ranking equal or above average in the sector and 0 otherwise (ranking below average in the sector)
ENV_dummy	Dummy variable = 1 if firms have an environmental ranking equal or above average in the sector and 0 otherwise (ranking below average in the sector)
C_S_dummy	Dummy variable = 1 if firms have a business behaviour ranking (towards customers and suppliers) equal or above average in the sector and 0 otherwise (ranking below average in the sector)

Table 4b. Descriptive Statistics of CSR Variables

Variable	Mean	SD	Min	Max
HR_dummy	0.66	0.47	0	1
ENV_dummy	0.67	0.46	0	1
C_S_dummy	0.64	0.47	0	1

Table 4c. CSR Variables per Year (% of firms above the sectoral average)

Year	HR	ENV	C_S
2002	75	78	82
2003	69	71	66
2004	72	68	65
2005	67	65	64
2006	66	70	67
2007	65	66	63

Table 4d. Correlation Matrix for CSR Variables

CSR dummies	HR	ENV	C_S
HR	1		
ENV	0.4591	1	
C_S	0.4251	0.4391	1

Chi-2 statistic is 0.001 for all pairs

Table 5a. Definition of CSR States

CSR practices	Combinations
Ranking below average on the three criteria	(000)
Ranking above average on Human Resources only (HR)	(100)
Ranking above average on Environment only (ENV)	(010)
Ranking above average on Customers and Suppliers only (CS)	(001)
HR & ENV	(110)
HR & CS	(101)
ENV & CS	(011)
HR, ENV & CS	(111)

Table 5b. Descriptive Statistics of CSR States

CSR states	% of observations
(111)	45
(110)	12
(000)	9
(001)	8
(011)	8
(101)	8
(100)	5
(010)	5

Table 6. GMM System Estimation – CSR States

Variables	Tobinq	
	Coeff	SE [a]
Lag Tobinq	0.557***	0.117
State111 (HR, ENV & CS)	0.166	0.173
State110 (HR & ENV)	0.316	0.203
State100 (HR)	0.419**	0.205
State001 (CS)	0.192	0.235
State010 (ENV)	0.266	0.228
State011 (ENV & CS)	0.333	0.220
State101 (HR & CS)	0.108	0.218
Ln_Assets	-0.174***	0.044
Ln_Sales	0.066***	0.022
RD_ratio	1.603***	0.318/
NoRD_dummy	0.016	0.027
Debt_ratio	0.235**	0.120
DJSTOXX600 index	0.156***	0.051
Advertising_ratio	-0.054	0.044
Constant	1.373***	0.353
Year dummies	Yes	
Sector dummies	Yes	
Countries dummies	Yes	
AR1	p = 0.009	
AR2	p = 0.197	
Hansen test	p = 0.721	

[*] Significant at 10%; [**] significant at 5%; [***] significant at 1%.
[a] Robust standard errors are reported.

Table 7. Tests for Supermodularity and Submodularity

CSR pairs	Supermodularity test	Submodularity test
HR and ENV	0.3772*	0.1213*
HR and CS	1.5267e-012**	3.3672
ENV and CS	0.6529	0.1348*

Based on Kodde and Palm (1986). The critical values provided by Kodde and Palm for α =0.25 are 0.455 and
2.090.

If the test value is below 0.455, the null hypothesis of supermodularity (submodularity) is accepted, and
if the test value is above 2.090, the null hypothesis is rejected. For test values between the two critical values,
the test is inconclusive.

The values marked * support the null hypothesis of supermodularity or submodularity.
The values marked ** support the null hypothesis of supermodularity and reject the null hypothesis of
submodularity.
The values marked *** support the null hypothesis of submodularity and reject the null hypothesis of
supermodularity.