Chapter 8
Good Enough! Are Socially Responsible Companies the More Successful Environmental Innovators?

Christiane Reif and Sascha Rexhäuser

8.1 Introduction

In the last years, environmental awareness has been on the rise especially in the societies of industrialized countries. Consumers are willing to pay (WTP) a price mark-up for 'green' products. This provides firms with the opportunity to gain profits and separate themselves from competitors by offering such products (Russo and Fouts 1997). The industry makes use of this trend by supplying adjusted products during whose production process environmental and sustainable aspects are considered. These often called 'green' products can be subsumed as impure public goods in economic literature (see e.g. Kotchen 2006). It is noticeable that more and more companies appear to have become socially and environmentally responsible on a voluntary basis in recent years (Poddi and Vergalli 2009). These voluntary actions of firms are called Corporate Social Responsibility (CSR). Firms can reveal their over-compliance with unobservable attributes through voluntary programs with publicly available information. Bénabou and Tirole (2010) classify this phenomenon as delegated philanthropy of stakeholders. Amongst others, Arora and Cason (1995) provide empirical evidence and Arora and Gangopadhyay (1995) refer to the theoretical background on vertical differentiation. This voluntary social or environmental action may be driven by the demand side of 'green' consumers or 'green' investors, on which we base the considerations of our analysis in this chapter.[1]

We concentrate on voluntary actions of firms in the environmental context. Communicating the environmental performance of a firm can help this firm in its

[1]Lyon and Maxwell (2008) additionally distinguish cost saving considerations and the avoidance of further threats of regulation as further reasons for such self-regulation.

C. Reif (✉) · S. Rexhäuser
Centre for European Economic Research (ZEW), Mannheim, Germany
e-mail: reif@zew.de

J. Horbach, C. Reif (eds.), *New Developments in Eco-Innovation Research*, Sustainability and Innovation, https://doi.org/10.1007/978-3-319-93019-0_8

competition for socially responsible clients (Kitzmueller and Shimshack 2012). The firm knows about its environmentally friendly activities, but for its consumers, employees and investors, it is not easy to obtain, aggregate or compare this information (Bénabou and Tirole 2010). Products can carry information on their environmental performance but not directly on their production process.[2] We argue that CSR can carry unobservable organizational qualities to reduce information asymmetry. We base this on the signaling model explained by Spence (1973) for the job market context and applied to the financial market by e.g. Ross (1977) or Bhattacharya (1979), in which signals serve as information on unobservable attributes (see Spence 2002).[3] We apply the idea of reputational economies of scale by Wernerfelt (1988) to our approach. Note that CSR does not signal the specific attributes of one product, but the firm's environmental R&D activity as a whole. CSR certifications—such as the Global Reporting Initiative (GRI)—are regarded as credible signals to transport firm attributes which cannot be observed easily and build up reputation (see e.g. Akerlof 1970; Toms 2002). Like Terlaak and King (2006), we assume that CSR signals these desired qualifications of firms, in our case information about the environmental attributes of a firm. Thereby it enhances the firm's reputation which is rewarded at the market by consumers, investors or business partners.

The research question is whether a joint strategy of environmental innovation and CSR engagement leads to higher financial performance than either one or none of them. If combined they could signal green attributes of firms. We use the Thompson and Reuters ASSET4 (A4) database of large global companies in panel-structure to analyze the long-term effects of such a joint strategy on firms' market value accounted for by the price-to-sales ratio. The underlying assumption is that CSR signals the environmental performance of a firm or in our approach the environmental R&D commitment. It indicates not only a firm's current activity, but also its long-term commitment to environmental responsibility.

The results support the view that the two strategies (environmental innovation and certified CSR) act as strategic complements in terms of a company's market value. Introducing a single strategy alone did not significantly affect financial performance while companies that adopted both strategies jointly significantly increased their market value compared to the control group. In this sense, the results suggest that a credible signal is needed to successfully disclose otherwise private information on companies' environmental performance.

[2] Akerlof (1970) originally addressed the problem of information asymmetry that arises either from adverse selection or from unobservable attributes (moral hazard).

[3] Please see Riley (2001) for an overview and discussion on the literature of signaling.

8.1.1 Related Literature

In the empirical research on CSR, an overwhelming number of studies addresses the connection of CSR and financial performance (FP), mostly focusing on how CSR influences financial performance.[4] Cochran and Wood (1984), Pava and Krausz (1996), as well as Griffin and Mahon (1997) provide literature reviews of early research. The meta-analyses by Orlitzky et al. (2003) or Margolis et al. (2007) indicate a positive correlation of CSR and FP.

However, empirical analyses hardly take innovation as a factor into account. Hart and Ahuja (1996) include innovation in form of R&D per sales as a control variable in their analyses of how CSR affects different types of operational and financial performances. They observe a positive effect of preventing pollution on financial performance. McWilliams and Siegel (2000) base their empirical research on two main arguments: innovation has a positive effect on FP, and CSR and innovation are strongly correlated. They prove that ignoring innovation might lead to an overestimation of the CSR effect on financial performance. Hull and Rothenberg (2008) extend the study by McWilliams and Siegel (2000) based on the assumption that firms can differentiate themselves from others via innovation or CSR. Their results suggest that CSR positively influences FP, furthermore that innovation is an important explanatory variable in this context, and that innovation and CSR are substitutes in terms of firm differentiation. Another study based on McWilliams and Siegel (2000) is conducted by Lioui and Sharma (2012), who examine how environmental CSR affects return-on-assets (ROA) and Tobin's Q directly and indirectly via R&D. They explain the negative direct effect of CSR on FP with the costs of CSR measures and attribute the positive indirect effect to more efficient R&D (Lioui and Sharma 2012). The study by Cavaco and Crifo (2014) is the only example known to us using a complementarity approach in the CSR context. They analyze three dimensions of CSR: responsible behavior towards employees, customers and suppliers, and the environment. They find that firms caring about employees and at the same time about customers and suppliers can gain profits. Furthermore, firms should decide on either environmentally friendly behavior or responsible behavior towards customers and suppliers and not engage in both of them at the same time.

Beside these studies which mostly use scores as an overall indicator for a firm's social and environmental activities, research with a focus on environmental performance is related to our analysis. This literature is strongly connected to the Porter hypothesis, stating that environmental regulation implies innovation and in turn generates a competitive advantage (see Porter and van der Linde 1995). Rexhäuser and Rammer (2014) test the Porter hypothesis for German companies and find that it does not hold in general and depends on the type of environmental innovation. A

[4]The term Corporate Social Responsibility (CSR) is not commonly defined. In literature and practice, several definitions exist, but two common aspects of CSR can be found in these definitions: CSR activities relate to social and environmental issues and go beyond legal requirements. For our analyses, we apply this definition.

study closely related to the CSR context by Klassen and McLaughlin (1996) empirically examines the effect of environmental awards on financial performance. In their event study, they find significantly positive effects. Another study by Konar and Cohen (2001) shows that negative environmental performance (like emitted toxic chemicals and lawsuits) affects financial performance negatively. Russo and Fouts (1997) use environmental ratings as environmental performance indicators and observe a positive impact on financial performance. Research approaches using panel data have been developed in the last years to respond to the criticism of not considering unobserved firm heterogeneity in cross-sectional studies. Among them is a study on US firms by King and Lenox (2001), showing that firms' attributes may drive the effect on financial performance. Elsayed and Paton (2005) find a neutral effect of environmental performance on financial performance in a dynamic panel data analysis for UK firms, which is confirmed by Telle (2006) for Norwegian firms. Additionally, empirical studies on environmental management systems (EMS) are connected to research on environmental performance and its effect on a firm's performance. Studies on the determinants of environmental management systems reveal that consumer preferences have a strong impact on firms' engagement in EMS certification (Nakamura et al. 2001; Potoski and Prakash 2005; Nishitani 2009; Nishitani 2010).[5] In contrast, Harrington et al. (2008) find that firms' internal factors are the driving forces for implementing environmental management.

However, research especially on the ISO 9000 and ISO 14000 as certified standards (see Heras-Saizarbitoria and Boiral 2013 for a literature overview) is more related to the signaling concept. Heras-Saizarbitoria and Boiral (2013) categorize signaling models as non-technical, theoretical approaches. Terlaak and King (2006) apply certified standards to the signaling model and find that the ISO 9000 certification leads to a competitive advantage, especially in large and advertising-intensive industries with high information costs. However, there are studies that do not find support for the ISO 14000 certification having a positive effect on financial performance (e.g. Heras-Saizarbitoria et al. 2011 for Spanish firms) or even a negative effect on the market value (Cañón-de-Francia and Garcés-Ayerbe 2009). Nevertheless, Toms (2002) shows for UK firms that the disclosure of environmental activities in annual reports creates reputation, which in turn may lead to a competitive advantage.

These studies analyze whether a single pro-environmental activity leads to positive effects on financial performance. We, in contrast, focus on the effect of joint activities. We investigate whether a CSR measure signaling pro-environmental action is complementary to environmental innovations in such a way that the joint presence of the two would generate higher profits, or if a substitutive character can be verified.

[5]In contrast, Harrington et al. (2008) find that firms' internal factors are the driving forces for implementing environmental management.

8.1.2 Hypothesis and Basic Complementary Model

We analyze the joint effect of green innovation and CSR on FP. We expect that CSR increases the marginal financial returns by disclosing a firm's environmental innovation compared to a control group. The underlying assumption is that firms in which both CSR and environmental innovations are present can differentiate themselves from their competitors by verifying their environmentally friendly behavior through CSR and their ongoing dedication to the future through today's R&D spending. Thus, they may convince stakeholders such as consumers, investors, and trading partners with their reputation.

We relate this assumption to the signaling hypothesis and the resource-based view (RBV) of the firm. The resource-based view (RBV) of the firm goes back to Penrose (1959). It takes the perspective that a firm is a bundle of resources (Wernerfelt 1984) with the main assumptions of resource heterogeneity and resource immobility (see Bowen 2007). Therefore, the RBV takes the standpoint that competitive advantage is created within the firm depending on the characteristics and usage of its resources. Thus, these specific firm capabilities can generate a competitive advantage in the long-run. According to Branco and Rodrigues (2006), reputation is an intangible resource which could be affected by a firm's CSR activity. As such, CSR creates reputation and in turn increases financial performance (see e.g. McGuire et al. 1988; Waddock and Graves 1997), which is described as lead-lag relationship by Preston and O'Bannon (1997).[6] Also the returns to R&D efforts are hard to observe (see e.g. Aboody and Lev 2000; Chauvin and Hirschey 1994) and can be seen as intangible assets. We assume that CSR serves as a signal to overcome this information asymmetry by at least partially disclosing a firm's environmental activities and thus, to state its environmental commitment. This in turn helps a firm to create a positive reputation and trustworthiness and might also support the company in vertical differentiation from their competitors (see e.g. Fombrun 1996; Fombrun and Shanley 1990).

Theoretically we can base our assumptions on the complementarity approach. Complementarity (in the sense of Edgeworth) of firm strategies means that engaging more in one activity increases the marginal returns of engaging more in the other. In our case, certified CSR may signal environmental responsibility and thus increase the returns to green R&D by making stakeholders aware of this. In principle, there are two ways to estimate such a relationship: the adoption approach and the productivity approach, which is central to the present paper.[7] The productivity

[6] In the environmental context, Hart (1995) or Russo and Fouts (1997) are examples of empirical research on the RBV.

[7] Loosely speaking, the adoption approach relies on the correlation of two firm strategies in order to account for complementarity. Note that this approach is only valid in case of continuous strategic measures (Miravete and Pernías 2010) and thus not applicable in this paper. The adoption approach can be traced back to the work of Arora and Gambardella (1990). They show that a positive covariance among a pair of activity variables indicates complementarity if the activity variables are conditioned on any other firm-specific characteristics. For an overview of empirical studies, please see Brynjolfsson and Milgrom (2013).

approach is not restricted to continuous variables and accounts for the performance effects of the potentially complementary variables with respect to an objective function—in our case financial performance.

Based on Milgrom and Roberts (1990), who show that the concept of complementarity is directly related to the supermodularity of the objective function, we can impose an order on each pairwise combination of the variables. We begin with the smallest element in the order, {0,0}, which, in this case, means that neither CSR nor environmental innovation is carried out. Elements ranked higher in this order, denoted as {1,0} and {0,1}, represent either environmental innovation only or exclusive CSR engagement. Finally, the highest element in this order, {1,1}, stands for the joint use of both firm strategies. The condition implies that adopting both strategies jointly leads to a higher performance than adopting both of them in isolation, simply because one increases the marginal returns of the other. Formally, the condition for supermodularity and complementarity reads as follows:

$$f(1,0) + f(0,1) \leq f(1,1) + f(0,0), \tag{8.1}$$

where *f*(.) represents the objective function (see Milgrom and Roberts 1990). Based on the complementary approach we formulate the following hypothesis:

> Firms engaged in both—environmental innovations as well as CSR—can gain ceteris paribus better financial performance.

As such, we analyze the joint presence of environmental innovation and CSR and compare their effect on financial performance to firms that have neither introduced environmental innovations nor CSR or only one of them.

8.2 Database and Choice of Variables

8.2.1 Database

We base our research on worldwide company panel data from the Thompson and Reuters ASSET4 (A4) database,[8] which allows us to get a better insight into the process organization of a company than CSR score data alone (as for example the Kinder, Lydenberg, Domini database, which is often used in the CSR context). The database mainly includes large companies based in the US. The unbalanced panel contains a collection of environmental, social, governance and financial data on more than 3000 global companies listed in major indices (e.g. S&P 500, MSCI World Index, Stoxx 300, Nasdaq, ASX 200). Publicly available information about a company (e.g. reports) is gathered yearly (beginning in 2002) by specially trained analysts with an increasing number of screened companies. Our sample extends over the years 2005 to 2009 as an unbalanced panel to ensure the availability of a two-year time lag for each variable (see

[8]The database can be accessed via the provider Thompson and Reuters.

Fig. 8.1, Appendix). The restricted sample for our estimations consists of 6737 observations including 1945 firms. Besides various factors for CSR characteristics, the dataset provides a rather limited amount of information on central firm-specific factors likely affecting firms' stock market value. Nevertheless, the panel data structure allows us to formally test whether CSR complements firms' environmental innovations in terms of financial performance or has a substitutive character.

8.2.2 *Choice of Variables*

8.2.2.1 Dependent Variable Financial Performance

The results of empirical analyses on the relation between a specific CSR activity and a specific FP strongly depend on how CSR and FP are measured: concerning CSR, if it is business-related or not and regarding FP, if it is an accounting-based or a market-based measurement (see Margolis et al. 2007). We analyze the effect of the joint presence of environmental innovation and CSR on the financial performance of a firm. This approach calls for market-based measurement of financial performance, replicating the long-term and future-oriented perspective. Therefore, we use the price-to-sales ratio (P/S_{it}) as a market-based way of measuring financial performance (see Pava and Krausz 1996, see Orlitzky et al. 2003, Margolis et al. 2007). It reflects the value placed on sales by past performance, other companies or the market. The profit margin affects the price-to-sales ratio and therefore, is an appropriate indicator for market power. In our sample the *P/S* variable shows a right-skewed distribution, so we use the logarithm of firm *i*'s *P/S*.

8.2.2.2 Environmental Innovation and CSR

Our complementary approach is based on the consideration that CSR signals a firm's engagement in environmentally friendly production to stakeholders. These stakeholders might be skeptical about firms' self-reported CSR activities. Certification from third parties of a company's CSR activity can serve as a signal which creates credibility and may thus support stakeholders in their decisions; moreover the respective firm can gain benefits from spreading this information. This is in line with findings by Terlaak and King (2006), who apply the signaling theory to certified management standards to overcome information asymmetries resulting in a competitive advantage.

In the database, the CSR indicator related to our approach is the dichotomous variable *Global Report Initiative* (CSR_{it}).[9] This variable reveals if companies publish their CSR report according to the Global Reporting Initiative (GRI) guidelines and it

[9]The A4 database offers other variables on CSR but the GRI fits our research question best and the database provides enough data points for the analysis.

serves as a proxy for firms' CSR performance. These guidelines are developed to standardize sustainability reporting and create transparency and comparability of companies around the world. Reports according to the GRI guidelines can be treated as a method of certification because GRI reporting comprises detailed information (over 100 indicators on firms' sustainability in the economic, environmental, social, and governance areas) and a third party ensures that the data is in accordance with the guidelines. The indicator may only suggest if the firm reports according to the GRI guidelines and not if the firm is really engaged in CSR activities. Nevertheless, we assume that only firms engaged in CSR activities actually report on them and in turn decide if they report in such detail as demanded by the GRI.

In our approach, we focus on the voluntary action of a firm in the environmental context. Therefore, the appropriate innovation variable available in the database is the dichotomous variable named environmental R&D ($Green_{it}$).[10] It provides information on whether the firm invested in R&D related to environmentally friendly products and processes to reduce emissions and resource consumption. This allows us to categorize environmentally and non-environmentally innovative firms. Nonetheless, the dichotomous variable is only an approximate value for innovation, as especially for large companies it is not clear which efforts they have made and how this affects the environmental activity of the respective firm.[11] Current environmental R&D investments are an indicator for the future market value of a firm. However, this kind of innovation is not easily observable for customers, investors or other business partners. Hence, it is plausible to assume that CSR might help to overcome this information asymmetry in the case of environmental R&D investment.

8.2.2.3 Explanatory and Control Variables

In the A4 database, additional variables illustrating market power, like market share or the Herfindahl index, are not available. This is especially true for the large firms listed on the stock exchange and included in the A4, which are operating globally and thus have no clear cut geographic market definition. Due to this diffuse market definition, using such market power indicators is questionable, as Aghion et al. (2005) point out. Alternatives like the Lerner index (see e.g. Aghion et al. 2005) or the price-to-cost ratio (see e.g. Gorodnichenko et al. 2010) are also not included in the A4 database. Nevertheless, the panel data structure allows controlling for unobservable but time consistent factors of market power. Nickell (1996) explains that the changes of the unobservable factors correlate with the changes of the observable variables. In our case the inclusion of the lagged price-to-sales ratio

[10]For a deeper discussion on R&D as innovation input, please see e.g. Kleinknecht et al. (2002) or Smith (2005).

[11]This is the only indicator in the A4 database for environmental R&D investments which is usable for the analyses. The A4 data on environmental R&D investment costs provides not enough data for the analysis.

(*lag(P/S)$_{it}$*) controls for these unobservable factors and at the same time it considers that past financial performance may explain current financial performance.

Another explanatory variable for financial performance, especially from an investor's perspective and if measured by a market-based variable, is a risk parameter. The risk coefficient beta as parameter for stocks' volatility, which measures the risk of an investment, reflects the riskiness of the returns of a firm. Risk, which might affect future financial performance, has not been adequately taken into account in most previous empirical studies (see criticism by Orlitzky 2005, Margolis et al. 2007, Cochran and Wood 1984). CSR can serve as a risk management instrument to reduce a firm's risk (Husted 2005). Orlitzky and Benjamin (2001) provide evidence for this link between a firm's CSR and its financial risk in their meta-analysis. Therefore, we include the variable beta ($Beta_{it}$) measuring the market risk.

Moreover, business cycles, influencing stock market values, might cause stock market prices to differ across countries and time. Thus, we need a time trend control that varies across countries. This effect is assumed to have a very immediate impact, so no time lag is included. In addition, it is reasonable to consider the business cycle as exogenous. Therefore, information on real GDP (growth) by country and year is linked to the A4 database based on firms' country affiliation and included as a control variable ($GDP\text{-}Growth_{it}$).

Patents are indicators for a temporarily limited monopoly and an approximate measure for the stock of intangible assets. Companies holding patents have a technological advantage, which can be the reason for price differences resulting in better performance. The benefit of using US patents is their consistent measurement method and the relevancy for firms holding US patents. We use the logarithm of the number of patents (*ln(Patents)$_{it}$*) held by a company in a specific year as provided by the A4 database for our calculations because we assume that the stock of patents affects *P/S* in the same time period and is not time lagged.

Additionally, the age of a company might influence its financial performance either positively through learning effects, or negatively because of its inability to adjust to new challenges. Hopenhayn (1992) shows under which circumstances older firms can gain higher profits. Age is thus an important factor when measuring financial performance and we include the age of the company as an explanatory variable (*ln(Age)$_{it}$*). Furthermore, we control for the size of the company measured by sales in logarithmic form (*ln(Sales)$_{it}$*). Labor productivity is included as the logarithm of the number of employees by sales (*ln(Labor/Sales)$_{it}$*).

8.3 Results

8.3.1 Descriptive Statistics

As in the database, the restricted sample of 6737 observations mainly comprises the following countries: the United States (33%), Japan (18%), and the United Kingdom (14%). The European countries represent about 39% of the observations.

Concerning the distribution of observations by continents, Fig. 8.2 (Appendix) shows that most relate to Europe, the US, and Asia. Especially for Europe and Asia, there are more observations of firms engaged in both strategies. Furthermore, the sample covers the 12 industry sectors according to the Standard Industrial Classification (SIC) (Table 8.4, Appendix). The finance, insurance and real estate sector are highly represented in our sample (19%), followed by the transport sector (13%). Nevertheless, the various manufacturing industries account for almost half of the observations in the sample (43%). As expected, firms are innovators or are engaged in both firm strategies, particularly in the manufacturing sectors.

Table 8.5 (Appendix) provides an overview of the chosen variables with a short explanation, together with the mean, the standard deviation, and the minimum and maximum values. We focus on the two variables of interest—environmental innovators and CSR engagement—for the further descriptive analyses. There are 1039 observations of environmental innovators and 1501 observations on CSR engagement over the years 2005–2009 (Table 8.6, Appendix). As the number of observations varies in the unbalanced panel, also the number of firms that reported environmental R&D and CSR varies over the period. The share of green innovators adds up to over 5% in each year and the share of firms carrying out CSR accounts for more than 8% in each year.

Although the key variables of interest (i.e. whether CSR and environmental R&D are implemented) are binary indicators, they vary considerably over time within the firms. 33.26% of the 1945 firms in our sample implemented CSR for at least one year, whereas environmental R&D has been reported at least once for 24.27% of the firms. Approximately 9.51% of the firms reported to have CSR in place in all observed years. The respective number of environmental R&D is much lower, namely 6.84%. More interestingly, 22.51% of all firms introduced CSR in a certain year and stuck to CSR in all the following years. Approximately 67.70% of all firms implemented CSR for at least one year. 15.42% of all firms implemented environmental R&D in a certain year and stuck to it in all the following years. This means 63.56% of all the firms carried out environmental R&D at least in one year. 2% of all 1945 firms changed their engagement over time with respect to R&D and 1.23% with respect to CSR activities. Figure 8.3 (Appendix) shows the number of observations within the period of 2005–2009 for the four exclusive types of engagement. Throughout these years, most companies were not engaged in either one of the strategies. However, in all years there are observations for all four categories.

A more detailed descriptive analysis of environmental R&D and CSR indicates a correlation between both strategies (Table 8.1). In the sample, the joint realization of environmental innovation and CSR occurs more frequently than the implementation of environmental innovation alone. Table 8.1 also shows the frequency under the assumption that both firm strategies are independent in parentheses. Interestingly, if both strategy variables were independent, we would expect that only 232 firms had introduced both strategies jointly. However, the firms that actually implemented both strategies amount to more than twice the number we would expect in case of independency. Together with the very high coefficient of association (Kendall's tau-b), Table 8.1 offers strong evidence for a high correlation between

Table 8.1 Adoption decision and relative frequencies

CSR				*CSR*			
Green	0	1	Total	*Green*	0	1	Total (%)
0	4754 (4429)	944 (1270)	5698	0	83.43% (77.73%)	16.57% (22.29%)	84.58
1	482 (808)	557 (232)	1039	1	46.39% (77.67%)	53.61% (22.33%)	15.42
Total	5236	1501	6737	Total	77.72%	22.28%	100.00

Expected frequencies appear in parentheses. Pearson chi^2 (1) = 696.3276, Pr = 0.000. Kendall's tau-b = 0.3215, $P > z = 0.0000$

environmental innovation and CSR. This is in line with considerations by Terlaak (2007) that firms in R&D intensive industries can gain a competitive advantage thanks to certified standards.

Nevertheless, the correlation alone, of course, is insufficient to show the presence of complementarity. Whether this correlation survives multivariate statistics controlling for any other influencing factors and whether it really stems from complementarity is subject to the following empirical analysis.

8.3.2 Estimation Strategy

We assume the market capitalization (or market value) to depend on the sum of the firm's physical assets and intangible (knowledge) assets. In our data the information on the physical assets of firms is not available. This, in combination with the difficulties to measure intangible assets, motivates the use of lagged market capitalization information to account for assets. Scaling market capitalization by firms' total sales is a frequently used[12] size-independent measurement for firms' value created by each single dollar of sales—the price-to-sales ratio, henceforth, is P/S_{it}. The resulting regression equation reads as follows:

$$\ln(P/S_{it}) = \beta_0 + \beta_p \ln(P/S_{it-1}) + \beta_{10} Green_{it} + \beta_{01} CSR_{it} + \beta_{11} Both_{it} + \boldsymbol{C}_{it}\beta_c + \in_{it},$$

where $\boldsymbol{C}_{it}$ is a vector of controls described above, $\in_{it} = u_i + e_{it}$ with u_i denoting firm-specific fixed effects and e_{it} representing an idiosyncratic error component. $Green_{it}$ accounts for the choice in favour of green innovation alone (i.e. without introducing CSR). CSR_{it} denotes that only CSR is in place. The dummy $Both_{it}$ indicates that both strategies are present so that no implementation of either strategy serves as the

[12]Comparable studies use measures like Tobin's q to relate environmental regulation or environmental innovation to firms' market value and financial performance, such as Dowell et al. (2000) or Konar and Cohen (2001).

reference group and thus, β_{00} is necessarily zero. Note that the price-to-sales ratio (P/S_{it}) is measured as the year-end value. Furthermore, the literature assumes a rather short event window in which upcoming information on firms' CSR activities and green innovation affect the market value (see e.g. Cañón-de-Francia and Garcés-Ayerbe 2009). However, we assume a rather long event window of a whole year. This is simply due to data availability. In this sense, the key variables of interest, $Green_{it}$, CSR_{it}, and $Both_{it}$, enter the model in the same year as the dependent variable. The strategy variables ($Green_{it}$, CSR_{it}) cannot be considered strictly exogenous, as they are endogenous choices of firms, which may be dependent on firms' market value. If providing a credible signal for sustainability really complements the investment in green R&D and translates into higher firm values, clever managers are likely to be aware of this issue. Since it is probable that good management is correlated with higher market values, omitting a control for management may cause the strategy variables to be biased, as management remains an unexplained error component and thus, $cov(Green_{it}, \in_{it,}) \neq 0$, $cov(CSR, \in_{it,}) \neq 0$, and $cov(Both_{it}, \in_{it,}) \neq 0$. Consequently, the empirical model needs to handle the endogeneity of the main variables of interest. An adequate solution does not consist in using one-year lagged values of the key variables of interest to rule out potential problems of endogeneity, as we assume a rather short-term event window in which upcoming information on CSR and green innovation can affect firms' market value. Therefore, we use lagged price-to-sales ratio information to control for physical and intangible assets.

However, incorporating a dynamic panel specification may cause potentially predetermined and thus not strictly exogenous regressors. Especially the lagged dependent variable is likely to be correlated with current errors via its correlation with past ones. Thus, it causes the classical linear regression model to be inconsistent, even if $\in_{it,}$ is not autocorrelated. Furthermore, neither the lagged dependent variable nor the vector of controls ($\boldsymbol{C}_{it}$) allow controlling for all differences in the price-to-sales ratio across firms. These unexplained differences in the between-dimension of the panel data (i.e. across firms) may be correlated with at least some of the regressors, leading to bias of their coefficient estimates. Therefore, we apply the Arellano-Bond dynamic panel data difference GMM estimator, which uses all available lags as instruments.

8.3.3 Empirical Results

As a first step, we test whether the traditional variables explaining growth in price-per-sales are in line with previous research concerning direction and size (Table 8.2). Therefore, we estimate *Model 1* with the logged growth in price-per-sales as dependent variable and without the complementary variables of interest.[13] The

[13]We conducted preliminary tests on fixed effects versus random effects models. First, the F-test on the null hypothesis of no fixed effects is rejected. The Hausman-Test with the null hypothesis of no

results verify that our dynamic approach including the one-year time lag of price-per-sales (*$ln(P/S)_{it-1}$*) is appropriate, as they are highly significant and size as well as direction are comparable to previous studies. The high negative coefficient shows marginally decreasing growth rates in P/S. A one percent increase in the lagged price-to-sales ratio is significantly associated with a 0.83% smaller growth rate in the price-to-sales ratio between periods *t* and *t*–1. Or in other words, the higher the price-to-sales ratio of firm *i* already is, the lower the rates of growth. Furthermore, risk ($Beta_{it}$) affects P/S growth negatively as expected and is highly significant. GDP growth ($GDP\text{-}Growth_{it}$) is highly significant and shows that the effects of business cycles varying across countries and time do influence the stock market value (scaled by total sales) very strongly. Sales ($ln(Sales)_{it}$) affect P/S growth significantly negatively. The variables productivity ($ln(Labor/Sales)_{it}$), age ($ln(Age)_{it}$), and stock of patents ($ln(Patents)_{it}$) are not significant.

Next, we provide the results for the dependent variable in logarithmic form ($ln(P/S)_{it}$) in *Model 2*. Compared to the growth of P/S_{it} as a dependent variable, the lag of P/S_{it} exerts a positive effect. This shows that previous performance influences future performance positively and that the performance value is exactly the same coefficient as in growth *Model 1* plus 1, of course. The other coefficients necessarily equal each other in size and direction.

After these preparatory steps, we turn to our research focus if CSR and green innovations are complementarily affecting financial performance. To that end, we apply the previously explained estimation strategy and base the further estimation on *Model 2* by additionally include the variables of interest. In our main estimation approach *Model 3*, we concentrate on the variables representing environmental innovation ($Green_{it}$), CSR (CSR_{it}), and employing both strategies jointly ($BOTH_{it}$) by including them in the estimations (Table 8.2).

In general, the additional variables in *Model 3* do not change the basic model results of *Model 2*. All the variables show the same direction as well as significance level and are similar in size. We apply now our attention to the variables in our focus. *Model 3* shows that a firm strategy of either carrying out green innovation or CSR alone has no significant impact on the financial performance of the firm measured in P/S. However, using both strategies at the same time exerts a highly positive and significant effect on a firm's P/S. Firms that had both strategies in place enjoyed an 8.46% higher price-to-sales ratio compared to the control group, i.e. firms that neither engaged in environmental R&D activities nor in CSR. Based on our assumptions, this suggests that reporting according to the GRI guidelines might help to signal pro-environmental action. Based on these results, we apply the complementarity approach with a one-sided t-test for complementarity against the null, $Green_{it} + CSR_{it} – BOTH_{it} \geq 0$, which supports complementarity. However, we can only reject the null hypothesis with a 90% probability. This would imply

correlation is rejected, too. Therefore, we use a fixed effects model with robust standard errors for the following dynamic panel estimations in a base model.

Table 8.2 Estimation results base models

	Model 1	Model 2	Model 3
	FE robust	FE robust	FE robust
Dependent variable	$gr(P/S)_{it}$	$ln(P/S)_{it}$	$ln(P/S)_{it}$
$ln(P/S)_{it-1}$	−0.830***	0.170***	0.166***
	(0.0236)	(0.0236)	(0.0235)
$Beta_{it}$	−0.233***	−0.233***	−0.232***
	(0.0326)	(0.0326)	(0.0326)
$GDP\text{-}Growth_{it}$	3.460***	3.460***	3.492***
	(0.626)	(0.626)	(0.623)
$ln(Sales)_{it}$	−0.474***	−0.474***	−0.476***
	(0.0441)	(0.0441)	(0.0441)
$ln(Labor/Sales)_{it}$	−0.0567	−0.0567	−0.0545
	(0.0430)	(0.0430)	(0.0428)
$ln(Patents)_{it}$	0.00244	0.00244	0.00237
	(0.00517)	(0.00517)	(0.00514)
$ln(Age)_{it}$	−0.0781	−0.0781	−0.0715
	(0.105)	(0.105)	(0.104)
$Green_{it}$			0.00688
			(0.0261)
CSR_{it}			0.0285
			(0.0204)
$BOTH_{it}$			0.0846***
			(0.0280)
Constant	10.54***	10.54***	10.56***
	(0.967)	(0.967)	(0.966)
Observations	6737	6737	6737
R^2 within	0.620	0.532	0.533
Rho	0.819	0.819	0.818
Test for complementarity: H_0 (full test): $Green_{it} + CSR_{it} - BOTH_{it} \geq 0$			
Test statistic *p*-value			2.10 0.0736

Note: The model includes four jointly significant year dummies. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

complementarity of green innovations and the GRI as a CSR activity, but the result might not hold for all industries or firms. We address this concern in our robustness check on manufacturing firms in the next subchapter.

The inclusion of the lagged dependent variable in the *Models 1–3* might violate the strict exogeneity assumption as explained above. Furthermore, the management decision on carrying out green innovations or engaging in CSR might also be endogenous. As the database does not provide adequate instruments, we estimate models with a dynamic GMM approach suggested by Arellano and Bond (1991). These types of models use estimations in differences, which allows applying lags as instruments. The model is based on a two-step GMM procedure to yield more efficient, i.e. heteroscedasticity robust, estimates. As such, *Models 4* include as an instrumentation vector the controls $\boldsymbol{C}_{it}$ in differences (Table 8.3). The potentially endogenous variable $ln(P/S)_{it-1}$ is instrumented by the second and any further time lags. The variables $Green_{it}$, CSR_{it}, $BOTH_{it}$ are instrumented by the first and further time lags as well as the moving average in *Model 4*.[14]

The instrument of $ln(P/S)_{it-1}$ is subject to endogeneity. The instruments for our variables of concern show in *Model 4* that they are exogenous at the 5% ($p = 0.051$) or the 10% level ($p = 0.344$). This would imply that they are appropriate instruments. With respect to the previous fixed effects estimations and the *Model 3* results in combination with the tests on exogeneity of the instruments, *Model 4* seems the best available estimation strategy for our data. The results for the estimations in *Model 4* mostly confirm the previous results in direction and values. *Model 4* shows again a positive effect of employing both strategies (innovation and CSR) together and this time the coefficient estimate is significant at the 10% level. Thus, with the moving averages as instruments the joint innovation-CSR strategy becomes significant and the size of the coefficient estimate is also close to the previous models. Nevertheless, the instruments in our models are restricted and might violate the strict exogeneity assumption. Concerning complementarity, we test whether condition (8.1) holds. We can reject the null hypothesis with 98% or more for *Model 4*. This implies complementarity of green R&D and CSR of environmental innovation and CSR in form of reporting according to the GRI guidelines as our basic *Model 3* also suggests.

8.3.4 Robustness Checks

In a first robustness check, the sample is restricted to the manufacturing industries (see shaded area in Table 8.4, Appendix). This limits our sample to 2878 observation and 820 firms observed in the years 2005 to 2009. Our estimation models confirm the previous effects of the traditional explanatory variables also for this restricted sample (Table 8.8, Appendix). Although the instruments seem to work better in the limited sample, the effects of the variables of interest show no clear direction when comparing the different models. Furthermore, the complementarity test rather implies no complementarity. For our hypothesis, this would mean that the firm's GRI reporting is a rather poor signal for CSR in the manufacturing sector. However, the descriptive analysis shows that in some of the manufacturing industries both strategies are implemented at the same time. Additional data especially on sectors with green R&D activity would be needed to verify the results and reveal in which sectors CSR reporting might serve as a signal for clients.

[14] In the appendix, we additionally provide *Model 5* where the variables $Green_{it}$, CSR_{it}, $BOTH_{it}$ are instrumented by the first and any further time lags and *Model 6* with the moving average.

Table 8.3 Estimation Results GMM Model 4

	Model 4
	GMM
Dependent variable:	$\ln(P/S)_{it}$
$ln(P/S)_{it-1}$	0.366***
	(0.0435)
$Beta_{it}$	−0.133***
	(0.0356)
$GDP\text{-}Growth_{it}$	1.808**
	(0.774)
$ln(Sales)_{it}$	−0.581***
	(0.0457)
$ln(Labour/Sales)_{it}$	−0.134***
	(0.0465)
$ln(Patents)_{it}$	−0.00294
	(0.00544)
$ln(Age)_{it}$	0.0541
	(0.0996)
$Green_{it}$	−0.0335*
	(0.0189)
CSR_{it}	0.00903
	(0.0180)
$BOTH_{it}$	0.0470*
	(0.0270)
Observations	6,737
Instruments	*2-year and any further lags of* $ln(P/S)_{it}$, *1-year and any further lags and moving average of* $Green_{it}$, CSR_{it}, $BOTH_{it}$
Arellano-Bond test for AR(1) in first differences	0.000
Arellano-Bond test for AR(2) in first differences	0.775
Sargan-Hansen test: *2-year and any further lags of* $ln(P/S)_{it}$	
Excluding group Difference	0.102 0.000
Sargan-Hansen test: *1-year and any further lags of* $Green_{it}$, CSR_{it}, *and* $BOTH_{it}$	
Excluding group Difference	0.000 0.990
Sargan-Hansen test: *moving average of* $Green_{it}$, CSR_{it}, *and* $BOTH_{it}$	
Excluding group Difference	0.000 0.714
Test for complementarity: H_0 (full test): $Green_{it} + CSR_{it} - BOTH_{it} \geq 0$	
Test statistic *p*-value	5.28 0.0108

Note: The model includes four jointly significant year dummies. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Another issue consists in employing the GRI as CSR variable, as it is just an approximate measurement of a firm's CSR activity. The sample includes a huge number of firms in the service sector. This leads to the questions of whether it is appropriate to test for green innovation activity and its possible disclosure via CSR, and if CSR variables other than GRI reporting might serve as better signals for environmental R&D. A further limitation might be that the dichotomous indicator only tells us if the firm reports according to the GRI guidelines, which does not necessarily reveal much about the specific activities. As the indicators provided by the database that suit our research focus are mainly dichotomous, we cannot overcome most of these concerns. In the following robustness check we assess whether an alternative CSR indicator might also serve as a signal for environmental R&D or if the results depend on the choice of the CSR variable, as Margolis et al. (2007) and Orlitzky et al. (2003) stress.

For this purpose we use the variable *External Sustainability Audit* (CSR_{it}). This variable reveals if the company assigns its CSR/Sustainability report to an external auditor. As such, the variable could signal the firm's social and environmental CSR activities. The traditional explanatory variables confirm the results of the previous models with the GRI reporting as CSR variable. However, the *Models 11–14* show different effects of the variables of interest concerning direction but no significant ones (Table 8.9, Appendix). The instruments in *Model 14* seem to fit best in comparison to *Models 12* and *13*. The complementarity test shows no complementarity at the conventional significance levels. This implies that the CSR variable *External Sustainability Audit* is a poor signal for green innovation in our sample.

8.4 Discussion and Concluding Remarks

The signaling literature suggests that signals serve as information on unobservable attributes (Spence 2002) to overcome information asymmetries. We apply the signaling theory to the environmental engagement of a firm. As such, we use the firm's green R&D activities, which are hard to observe for stakeholders. Therefore, the firm needs a signal to communicate its environmental activities to differentiate itself from its competitors and gain an advantage. CSR, which has become increasingly important in the last years, can verify a firm's pro-social and pro-environmental engagement and serve as a signal. This is a signal in the sense of Wernerfelt's (1988) reputational economies of scale, which creates reputation not only for one product but for the firm as a whole. As such, CSR is a source of capabilities in the resource-based view of the firm: CSR creates reputation and, in turn, leads to higher financial performance. We analyze if CSR as a signal complements the environmental R&D activity of a firm and whether a joint strategy leads to higher financial performance.

Using data on global companies from the A4 database, we examine if environmental R&D and reporting according to the GRI guidelines are complementary, and consequently we research, if the joint strategy leads to better financial performance.

Our different analyses rather support the hypothesis that a joint strategy leads to higher financial performance, although the effects are rather small. In other words, green innovators can verify their activity through GRI reporting and attract clients. Further research may determine how this works with specific clients, such as consumers or investors.

However, our results do not allow a conclusion on CSR in general, which our additional analyses with a different CSR variable reveal. We cannot conclude that CSR per se is beneficial for green innovators. As Orlitzky and Benjamin (2001) and Margolis et al. (2007) have already pointed out, the effect of CSR on the financial performance of a firm depends on the measurement of CSR. Our results support this viewpoint and reveal that not every kind of CSR is suitable to transport unobservable signals of firms' environmental R&D engagement. Furthermore, the descriptive statistics might explain that the relation of green R&D and CSR depends on firm location and industry. On the one hand, this supports the resource-based view of firms that creating reputation which in turn leads to higher financial performance depends on the uniqueness of capabilities and their specific usage. Therefore, R&D as well as CSR are not advantageous in general. On the other hand, the behavioral view comes into play suggesting that personal values are needed for a social firm strategy.This becomes especially apparent when we interpret our results against the background of the descriptive statistics, which state that in Europe and Asia more firms carry out both strategies jointly. Further research would be necessary to analyze if such values are more expected or more accepted by firms' stakeholders in these countries than in other ones.

Further limitations of our analysis accrue from data constraints. In particular, the different firm strategies might be subject to endogeneity as they could contribute to the same personal management values. Instrumentation via the lagged variables and the moving averages is limited. The results need to be verified with additional data, which may be possible in the future as more and more data on GRI reporting will be available. Moreover, as the ASSET4 database mainly provides dichotomous variables, which might not change much over time, further research with more detailed data would provide better insights. Another drawback is the composition of the sample with a huge number of firms in the service sector, which might report their CSR activity, but are not engaged in innovation.

Nevertheless, our study provides the first results on complementarity of green R&D and CSR related to the signaling theory. As such, it tries to overcome the drawback of previous cross-sectional analysis, which consists in not accounting for unobservable factors by using panel data. We can verify that the signaling effect of CSR strongly depends on the type of CSR.

Acknowledgements This work is part of the project Impact Measurement and Performance Analysis of CSR (Corporate Social Responsibility), funded by the EU (7th Framework Program), Brussels, BE. We are indebted to the participants of the seminars and workshops held in Évora, Frankfurt (Oder), Mannheim, and Toulouse for their comments.

Appendix

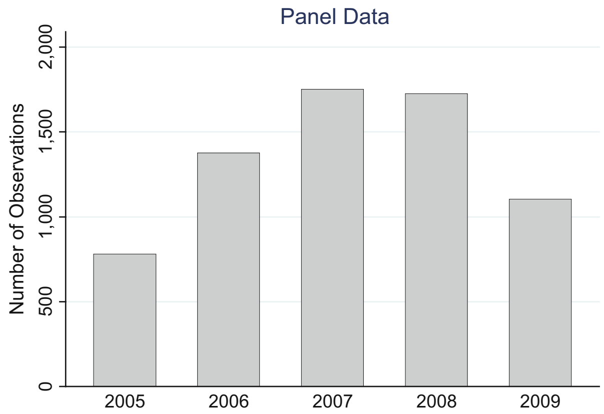

Fig. 8.1 Unbalanced panel data sample (6737 observations)

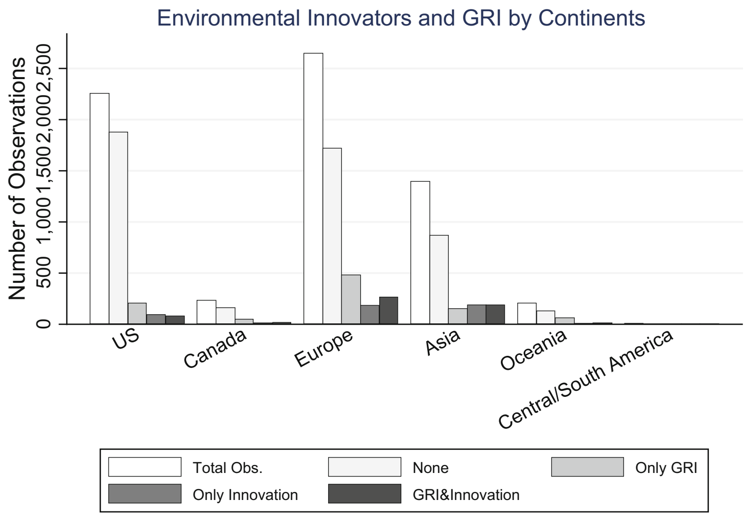

Fig. 8.2 Overview panel data and innovation and CSR categories by continents

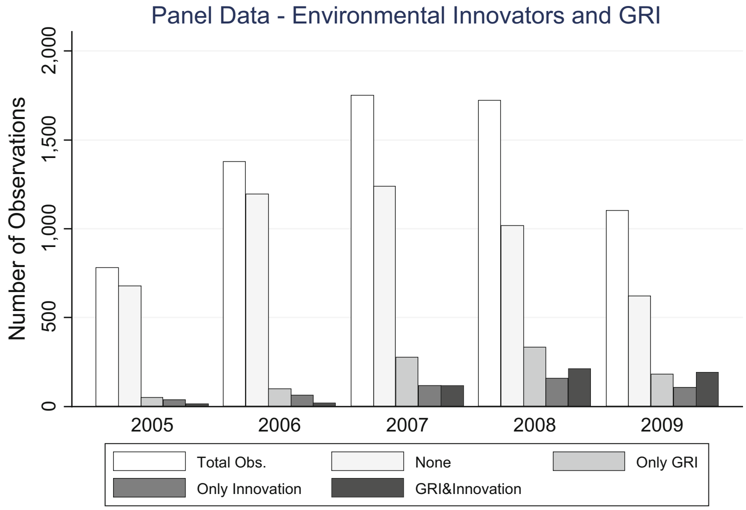

Fig. 8.3 Overview panel data and innovation and CSR categories

Table 8.4 Overview industry sectors (6737 observations)

Industry sectors SIC	No. of observations	Percent (%)
Mining	364	5.40
Construction	237	3.52
Manufacture food	297	4.41
Manufacture wood, paper, print	279	4.14
Manufacture chemicals	525	7.79
Manufacture metal, machinery, transport Eq.	698	10.36
Manufacture computers, electronic Eq.	480	7.12
Manufacture others	599	8.89
Transport, communication, electric	843	12.51
Wholesale and retail trade	583	8.65
Finance, insurance, real Estate	1281	19.01
Services	551	8.18
Total	6737	100.00

Table 8.5 Overview variables and descriptive statistics (6737 observations)

Variable	Definition	Mean (SD)	Min/Max
$ln(P/S)_{it}$	Logarithm ofprice-to-sales ratio	0.1759 (0.9624)	−2.2964/ 2.9498
$ln(Patents)_{it}$	Logarithm of US patents held by company	0.5109 (1.6150)	0/9.9739
$Beta_{it}$	Risk parameter beta	1.1060 (0.6208)	−2.4691/ 6.6454
$GDP\text{-}Growth_{it}$	Real GDP growth by country and year	0.0089 (0.0277)	−0.0854/ 0.1270
$ln(Age)_{it}$	Age of a company in logarithmic form	3.8521 (0.9357)	1.2528/ 6.2851
$ln(Sales)_{it}$	Logarithm of sales for company size	22.4038 (1.3987)	18.0315/ 26.7973
$Ln(Labor/Sales)_{it}$	Labor productivity of company as logarithm of employees by sales	−12.9804 (0.9110)	−18.1888/ −9.4769
$Green_{it}$	Dichotomous innovation variable environmental R&D	0.1542 (0.3612)	0/1
CSR_{it}	Dichotomous CSR variable on CSR reporting according to Global Reporting Initiative guidelines	0.2228 (0.4162)	0/1

Table 8.6 Overview environmental R&D and CSR variables

	Overall	Environmental R&D		CSR	
Year	No. of obs.	No. of observed firms with R&D	Share of observed firms with R&D (%)	No. of observed firms with CSR	Share of observed firms with CSR (%)
2005	781	51	6.53	66	8.45
2006	1377	82	5.95	119	8.64
2007	1751	234	13.36	394	22.50
2008	1724	372	21.58	547	31.73
2009	1104	300	27.17	375	33.97
Total	6737	1039	15.42	1501	22.28

GMM Estimators

Table 8.7 below provides the results for the basic GMM models, where the variables $Green_{it}$, CSR_{it}, $BOTH_{it}$ are instrumented by the first and any further time lags (*Model 5*) or the moving average (*Model 6*).

Compared to *Model 3*, the GMM estimation in *Model 5* shows smaller coefficients, except for the lagged P/S, and in some cases lower significance levels for the traditional variables influencing P/S. Nevertheless, the directions are comparable to the previous results. The coefficient estimates of the variables of interest, green innovation and CSR, again do not statistically differ from zero (however, their sign is

Table 8.7 Estimation Results GMM Models 5 and 6

	Model 5	*Model 6*
	GMM	GMM
Dependent variable	$\ln(P/S)_{it}$	$\ln(P/S)_{it}$
$ln(P/S)_{it-1}$	0.391***	0.409***
	(0.0491)	(0.0474)
$Beta_{it}$	−0.146***	−0.141***
	(0.0346)	(0.0348)
$GDP\text{-}Growth_{it}$	1.640**	1.606**
	(0.755)	(0.784)
$ln(Sales)_{it}$	−0.576***	−0.594***
	(0.0478)	(0.0473)
$ln(Labor/Sales)_{it}$	−0.111**	−0.130***
	(0.0449)	(0.0487)
$ln(Patents)_{it}$	0.000697	−0.000447
	(0.00547)	(0.00548)
$ln(Age)_{it}$	0.0837	0.0784
	(0.0932)	(0.0956)
$Green_{it}$	−0.00337	−0.0826**
	(0.0409)	(0.0359)
CSR_{it}	−0.0590	0.0118
	(0.0444)	(0.0246)
$BOTH_{it}$	0.114*	0.0166
	(0.0613)	(0.0345)
Observations	6737	6737
Instruments	*2-year and any further lags of* $ln(P/S)_{it}$*, 1-year and any further lags of* $Green_{it}$, CSR_{it}, $BOTH_{it}$	*2-year and any further lags of* $ln(P/S)_{it}$*, moving average of* $Green_{it}$, CSR_{it}, $BOTH_{it}$
Arellano-Bond test for AR (1) in first differences	0.000	0.000
Arellano-Bond test for AR (2) in first differences	0.713	0.636
Sargan-Hansen test: *2-year and any further lags of* $ln(P/S)_{it}$		
Excluding group Difference	0.041 0.000	0.000 0.000
Sargan-Hansen test: *1-year and any further lags of* $Green_{it}$, CSR_{it}*, and* $BOTH_{it}$		
Excluding group Difference	0.000 0.025	
Sargan-Hansen test: *moving average of* $Green_{it}$, CSR_{it}*, and* $BOTH_{it}$		
Excluding group Difference		0.000 0.001
Test for complementarity: H_0 (full test): $Green_{it} + CSR_{it} - BOTH_{it} \geq 0$		
Test statistic *p*-value	10.10 0.0007	5.17 0.0115

Note: The models include four jointly significant year dummies. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 8.8 Estimation results GMM models for manufacturing industries

	Model 7	*Model 8*	*Model 9*	*Model 10*
Dependent variable	FE robust	GMM	GMM	GMM
	$\ln(P/S)_{it}$	$\ln(P/S)_{it}$	$\ln(P/S)_{it}$	$\ln(P/S)_{it}$
$ln(P/S)_{it-1}$	0.111***	0.287***	0.350***	0.292***
	(0.0322)	(0.0786)	(0.0724)	(0.0683)
$Beta_{it}$	−0.197***	−0.111**	−0.107**	−0.102**
	(0.0461)	(0.0447)	(0.0450)	(0.0415)
$GDP\text{-}Growth_{it}$	3.005***	2.188*	2.346*	2.423*
	(0.977)	(1.302)	(1.356)	(1.311)
$ln(Sales)_{it}$	−0.434***	−0.532***	−0.563***	−0.596***
	(0.0917)	(0.0876)	(0.0974)	(0.0903)
$ln(Labor/Sales)_{it}$	−0.122	−0.142	−0.175	−0.190*
	(0.0775)	(0.0875)	(0.109)	(0.0969)
$ln(Patents)_{it}$	0.00259	−1.99e-05	−0.00371	−0.00455
	(0.00602)	(0.00627)	(0.00665)	(0.00678)
$ln(Age)_{it}$	−0.190	0.149	0.100	0.169
	(0.168)	(0.146)	(0.146)	(0.151)
$Green_{it}$	0.0140	−0.0160	−0.0805**	−0.0366
	(0.0320)	(0.0437)	(0.0406)	(0.0240)
CSR_{it}	0.0176	−0.134**	0.0127	0.00599
	(0.0285)	(0.0613)	(0.0432)	(0.0265)
$BOTH_{it}$	0.0488	0.000594	−0.0221	0.0103
	(0.0382)	(0.0925)	(0.0512)	(0.0347)
Constant	9.257***			
	(2.092)			
Observations	2878	2878	2878	2878
R^2	0.531			
Rho	0.841			
Instruments		*2-year and any further lags of* $ln(P/S)_{it}$, *1-year and any further lags of* $Green_{it}$, CSR_{it}, $BOTH_{it}$	*2-year and any further lags of* $ln(P/S)_{it}$, *moving average of* $Green_{it}$, CSR_{it}, $BOTH_{it}$	*2-year and any further lags of* $ln(P/S)_{it}$, *1-year and any further lags and moving average of* $Green_{it}$, CSR_{it}, $BOTH_{it}$
Arellano-Bond test for AR(1) in first differences		0.000	0.000	0.000
Arellano-Bond test for AR(2) in first differences		0.0639	0.0141	0.0248

(continued)

Table 8.8 (continued)

Dependent variable	*Model 7*	*Model 8*	*Model 9*	*Model 10*
	FE robust	GMM	GMM	GMM
	$\ln(P/S)_{it}$	$\ln(P/S)_{it}$	$\ln(P/S)_{it}$	$\ln(P/S)_{it}$
Sargan-Hansen test: *2-year and any further lags of* $ln(P/S)_{it}$				
Excluding group Difference		0.526 0.000	0.011 0.000	0.541 0.000
Sargan-Hansen test: *1-year and any further lags of* $Green_{it}$, CSR_{it}, *and* $BOTH_{it}$				
Excluding group Difference		0.000 0.921		0.000 0.998
Sargan-Hansen test: *moving average of* $Green_{it}$, CSR_{it}, *and* $BOTH_{it}$				
Excluding group Difference			0.000 0.300	0.000 0.503
Test for complementarity: H_0 (full test): $Green_{it} + CSR_{it} - BOTH_{it} \geq 0$				
Test statistic *p*-value	0.15 0.3472	4.76 0.0146	0.78 0.1890	1.02 0.1569

Note: The model includes four jointly significant year dummies. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

now negative). Concerning engagement in both strategies ($BOTH_{it}$), *Model 5* confirms the results from the basic models, as there is a positive effect on P/S but it is only significant at the 10% level. The test developed by Arellano and Bond (1991) for auto-correlation in an auto-regressive process of the first order (AR1) shows significant serial correlation but no significant evidence of serial correlation in the first-differenced errors at order two ($p = 0.713$). This allows us to use lags of more than two-years as instruments. The Sargan-Hansen test for over-identification against the null—i.e. that the vector of instruments is orthogonal to the vector of the errors (or against the null that the instruments are exogenous)—shows that the instrumentation of the variable $ln(P/S)_{it-1}$ is not strictly exogenous ($p = 0.000$). Unfortunately, the database does not provide better instruments and also estimations and tests with longer time lags reveal the same endogeneity problem. Therefore, we have to interpret the results with care. Although formal endogeneity is observable, it might not strongly affect the market value during the next year in reality as P/S is a year-end value. The tests for the subset of instruments with the lags of $Green_{it}$, CSR_{it}, $BOTH_{it}$ confirm exogeneity to be slightly over the 1% level. This might indicate that the strict exogeneity assumption could be violated.

Therefore, we use the moving averages of the innovation and CSR variables as instruments in *Model 6*. For the moving average we calculate the average of the sum of the current year, one-year, and two-year time lag for each of the variables $Green_{it}$, CSR_{it}, $BOTH_{it}$. In this model the traditional variables are similar to *Model 5*, except for the coefficient estimate of the stock of patents ($ln(Patents)_{it}$), which is not significant in all models. The variables of a pure CSR strategy and a joint CSR

Table 8.9 Estimation results GMM models for CSR variable sustainability external audit

	Model 11	*Model 12*	*Model 13*	*Model 14*
Dependent variable	FE robust	GMM	GMM	GMM
	ln(P/S)it	ln(P/S)it	ln(P/S)it	ln(P/S)it
lag-ln(P/S)$_{it}$	0.168***	0.390***	0.430***	0.391***
	(0.0235)	(0.0477)	(0.0469)	(0.0465)
Beta$_{it}$	−0.232***	−0.160***	−0.153***	−0.152***
	(0.0326)	(0.0353)	(0.0361)	(0.0365)
GDP-Growth$_{it}$	3.485***	1.390*	1.351*	1.576**
	(0.623)	(0.783)	(0.775)	(0.799)
ln(Sales)$_{it}$	−0.474***	−0.595***	−0.612***	−0.603***
	(0.0443)	(0.0477)	(0.0479)	(0.0461)
ln(Labor/Sales)$_{it}$	−0.0565	−0.106**	−0.126***	−0.119***
	(0.0431)	(0.0445)	(0.0470)	(0.0455)
ln(Patents)$_{it}$	0.00248	0.00235	−0.000962	0.00104
	(0.00516)	(0.00558)	(0.00568)	(0.00566)
ln(Age)$_{it}$	−0.0780	0.0866	0.109	0.0885
	(0.104)	(0.0949)	(0.0974)	(0.102)
Green$_{it}$	0.0264	−0.0450	−0.0560	−0.0154
	(0.0251)	(0.0564)	(0.0393)	(0.0197)
CSR$_{it}$	−0.00980	−0.0211	0.00375	0.00390
	(0.0276)	(0.0509)	(0.0351)	(0.0210)
BOTH$_{it}$	0.0443	0.0186	−0.0449	−0.00942
	(0.0312)	(0.0744)	(0.0423)	(0.0302)
Constant	10.54***			
	(0.969)			
Observations	6737	6737	6737	6737
R^2	0.533			
Rho	0.819			
Instruments		*2-year and any further lags of ln(P/S)$_{it}$, 1-year and any further lags of Green$_{it}$, CSR$_{it}$, BOTH$_{it}$*	*2-year and any further lags of ln (P/S)$_{it}$, moving average of Green$_{it}$, CSR$_{it}$, BOTH$_{it}$*	*2-year and any further lags of ln(P/S)$_{it}$, 1-year and any further lags and moving average of Green$_{it}$, CSR$_{it}$, BOTH$_{it}$*
Arellano-Bond test for AR(1) in first differences		0.000	0.000	0.000
Arellano-Bond test for AR(2) in first differences		0.750	0.540	0.679

(continued)

Table 8.9 (continued)

	Model 11	*Model 12*	*Model 13*	*Model 14*
Dependent variable	FE robust	GMM	GMM	GMM
	ln(P/S)it	ln(P/S)it	ln(P/S)it	ln(P/S)it
Sargan-Hansen test: *2-year and any further lags of* $ln(P/S)_{it}$				
Excluding group Difference		0.010 0.000	0.000 0.000	0.003 0.000
Sargan-Hansen test: *1-year and any further lags of* $Green_{it}$, CSR_{it}, *and* $BOTH_{it}$				
Excluding group Difference		0.000 0.022		0.000 0.681
Sargan-Hansen test: *moving average of* $Green_{it}$, CSR_{it}, *and* $BOTH_{it}$				
Excluding group Difference			0.000 0.004	0.000 0.453
Test for complementarity: H_0 (full test): $Green_{it} + CSR_{it} - BOTH_{it} \geq 0$				
Test statistic	0.53	1.58	0.02	0.00
p-value	0.2339	0.1042	0.4407	0.4766

Note: The model includes four jointly significant year dummies. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

and R&D strategy are not significant. However, now green R&D affects P/S significantly negatively (5% level) but only with a small coefficient. Again the Arellano-Bond test at order one shows significant serial correlation, but no significant evidence of serial correlation in the first-differenced errors at order two ($p = 0.636$). We have to reject the null hypothesis of exogeneity of the subsets of instruments at the conventional 10% or 5% levels for both subsets.

Anderson-Hsiao Estimator

Table 8.10 below provides the results for the basic dynamic model setup, in which the endogeneity of the lagged dependent variables, but not the endogeneity of the key variables of interest, has been accounted for.

The most obvious insight from this table is that the coefficient estimate of the lagged dependent variable is far away from plausible values and also from the very basic OLS estimates provided in Table 8.5. The reason probably is a considerable instrumental variable bias due to a weak instrument problem. Recall that the results from Table 8.10 rely on a mode setup where all variables enter the model in differences. Although the correlation of the price-to-sales ratio in period t and $t-1$ is relatively high (0.883), the correlation of the first differences and lagged first differences is very small (−0.2354) making it a bad instrument. Also the first stage regressions support this view. The coefficient estimate of the excluded instrument in the structural equation is relatively low; let alone the fact that its level of significance

Table 8.10 Estimation results Anderson-Hsiao estimator

	(App. 1)	(App. 2)
	AH robust	First stage
Dependent variable	$\Delta \ln(P/S_{it})$	$\Delta \ln(P/S_{it-1})$
$\Delta ln(P/S)_{it-1}$	−2.754**	
	(1.093)	
$\Delta ln(P/S)_{it-2}$		0.0478**
		(0.0198)
$\Delta Beta_{it}$	−0.397***	−0.0268
	(0.0756)	(0.0198)
$\Delta GDP\text{-}Growth_{it}$	30.02***	8.003***
	(8.807)	(0.292)
$\Delta ln(Sales)_{it}$	0.349	0.357***
	(0.413)	(0.0338)
$\Delta ln(Labor/Sales)_{it}$	0.0353	0.0357
	(0.0828)	(0.0282)
$\Delta ln(Patents)_{it}$	−0.00836	−0.00137
	(0.0107)	(0.00383)
$\Delta ln(Age)_{it}$	−0.0645	−0.0667
	(0.308)	(0.114)
$\Delta Green_{it}$	0.0558	0.0456**
	(0.0719)	(0.0184)
ΔCSR_{it}	0.106	0.0570***
	(0.0724)	(0.0140)
$\Delta BOTH_{it}$	0.207**	0.0809***
	(0.104)	(0.0221)
Constant	0.0412	0.0123
	(0.0277)	(0.00786)
Observations	5633	5633
R-squared		0.219
rho		

Note: Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

is rather small, which supports the concern of a weak instrument problem. In particular, the F-statistic of the excluded instrument in the first stage regression ($F = 5.81$) is far away from areas considered to support non-weakness of instruments. Staiger and Stock (1997) propose a rule of thumb of a value of ten for the first stage F-statistic of a single excluded instrument to provide evidence for non-weakness. The central insight from this simple experiment is straightforward. Even in this basic setup, which only addresses the endogeneity of one variable, namely the lagged dependent variable, the Anderson-Hsiao estimator performs rather poorly given our data as lagged differences of the price-to-sales ratio, which is only loosely correlated with current values. Therefore, further lags as instruments might help mitigate this problem as in the Arellano-Bond GMM case. In this sense, the Arellano-Bond estimator seems to be a better choice allowing more consistent estimates, at least in part.

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