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Links between sustainability-related innovation and sustainability management

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Abstract

This paper analyses the link between sustainability-related innovation and sustainability performance and the role that family firms play in this. This theme is particular relevant from a European point of view given the large number of firms that are family-owned. Governments often support environmentally and socially beneficial innovation with various policy instruments with the intention is to increase international competitiveness and simultaneously support sustainable development. In parallel, firms use corporate social responsibility (CSR) and environmental management systems partly in the hope that this will foster such innovation in their organisation. Hence the main research question of this paper is about the association of CSR and environmental management with environmentally and socially beneficial innovation and its determinants. Based on panel data, the paper analyses the link of corporate sustainability performance with sustainability innovation and the effect of being a family firm using panel estimation techniques. The paper discusses the results of the analysis, which point to a moderating role of family firms on the link of sustainability innovation and performance and assesses the policy implications of this insight.

Keywords: sustainability, innovation, management, quantitative methods, family firms

JEL classification: C30; L73; Q25

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INTRODUCTION

This paper analyses how corporate sustainability management activities associate with sustainability-related innovation in companies. The relevance of this question can be derived from a policy as well as a firm perspective. In terms of the former perspective, governments often support environmentally and socially (particularly) beneficial innovation with various policy instruments with the intention to increase international competitiveness and simultaneously support sustainable development. For example, the German secretary of state for the environment demands: “Germany should establish itself as a responsible energy efficiency and environmental technologist in the global division of labour between nations” (Gabriel, 2006). This perspective, which stresses the opportunities arising from sustainability-related innovation for increasing competitiveness is complemented by a risk-oriented view, which is explicated in the 7th Lifeworth Annual Review. The environmental managers surveyed for the review do not see sufficient progress with regard to reduction targets concerning e.g. climate change or poverty. One of the authors of the study hence stresses the „... need for a new mindset for corporate sustainability to stimulate innovation …” (Grayson, 2008). This challenge is also identified in a recent study of the consulting firm McKinsey. Its 2007 survey of 400 chief executive officers of global companies found 70% of the respondents considering a strategic approach to social and environmental issues as having very high or high priority. In a survey of 2002 that asked the same question, only 33% of the respondents considered this a very high or high priority. At the same time, the respondents to the McKinsey survey perceive significant challenges in the organisational implementation of such a strategic approach. Policy makers often consider EMS as one approach to achieve such a strategic integration. In particular, they perceive EMS as a means to push environmental innovation (as one specific sub-category of sustainability related innovation), and by analogy, one could generalise, that sustainability-related innovation could be driven by the totality of the sustainability management activities of a company. This related to the second perspective introduced above in that firms use CSR and environmental management systems partly in the hope that this will foster such innovation in their organisation (and ultimately governments support CSR and EMS partly because of this).

In the remainder of this paper, I initially review extant literature on the link between environmental and sustainability innovation and management activities. I then introduce a formal definition of sustainability innovation and derive research questions. Subsequently the data and the econometric methodology is reported. Following this, present results of and empirical study and conclude the paper with a discussion of their implications for policy, practice and future research.

LITERATURE REVIEW

A number of empirical studies have attempted to identify such determinants at the level of the firm as well as for aggregated industries (Jaffe and Palmer, 1997; Hemmelskamp, 1999; Brunnermeier and Cohen, 2003; Ziegler and Rennings, 2004; Rennings et al., 2005; Rennings et al., 2006).

Jaffe and Palmer (1997) analyse the influence of environmental expenditures on innovation activities based on panel data for the U.S. manufacturing sector. They find a positive influence of environmental expenditure on future research and development (R&D) expenditure, but not on the number of patent applications. However, Brunnermeier and Cohen (2003) criticise that the simultaneous influence of environmental expenditure on R&D expenditure and patent applications was not modelled and that the number of patent applications did not focus on environmental innovations only.

Hemmelskamp (1999) analyses data from the Mannheim Innovation Panel of 1993 based on ordered probit models with regard to the influence of a number of variables on five innovation objectives which he identified by means of factor analysis, amongst which are “development of environmentally-friendly products”, “reduction of environmental impacts from production”, “reduction of energy input” and “improvement of working conditions”. A focus of the analysis was an assessment of the influence of environmental regulation on innovation activities. This was modelled using an index which evaluated separately for each industry in the sample to which degree it is affected by different regulatory instruments such as taxes or standards (based on a fax survey of approx. 20 IHK managing directors across all federal states).

A limitation of the research of Hemmelskamp (1999) is that the underlying Mannheim Innovation Panel survey which generated the empirical data was not specifically oriented towards environmental innovations (Rehfeld et al., 2007), that the study did not involve panel data which may result in unobserved heterogeneity being a problem and that the regulatory instrument measure applied was empirically gathered somewhat casual.

Rennings et al. (2003; 2005; 2006) analyse in their broad-based empirical survey the effects of environmental management systems on firm-level innovation activities and competitiveness based on the European Eco-Audit and Management Scheme (EMAS). Using survey data and detailed case studies, they show that a stronger integration of innovation and environmental management can increase the competitiveness of firms. This finding is based on a telephone survey of 1277 EMAS-validated firms as well as detailed case studies. The analysis finds a positive effect on the realisation of environmental innovations and shows, that the environmental statements required under EMAS strengthen information spillovers in that they are used by other firms to generate ideas for own environmental innovations. A limitation of the study is that data was only collected for EMAS-verified firms, which limits the generalisability of the determinants and links identified.

Ziegler and Rennings (2004) in another study cast doubt on the effects of EMS implementation and if they are related to EMAS validation, since they do not find a significant effect of the latter. They analyse a sample of German firms with regard to the effect of EMS and of specific measures such as life-cycle analysis or existence of recycling systems on environmental product or process innovations. They apply binary probit and multinomial logit models. In the case of the former, only certification according to ISO 14001 has a significant positive effect on firms carrying out either environmental product or process innovations alone. In all other binary models (with product innovation only, process innovation only and simultaneous product and process innovation, respectively) neither ISO certification nor EMAS validation has an effect.

Individual measures however do have a significant positive effect. These measures also have a significant positive association with simultaneous product and process innovation in the multinomial logit models analysed. In these, also ISO 14001 certification has a significant positive effect.

The following section outlines the concept of sustainability-related innovation and discusses how evolutionary perspectives of cooperation and here in particular open innovation processes and user innovation, especially in the context of lead markets, matter for sustainability-related innovation. Based on this, it derives then research questions.

DEFINITIONS AND RESEARCH QUESTIONS

Defining sustainability-related innovation

Sustainable development is defined in the Brundtland Report "Our Common Future"as follows: "*Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (WCED 1987: 54). Yet, already the Brundland Report, immediately after this famous definition states that in terms of needs, the focus should particularly be on those of the poor in developing countries and in doing so provides an early link to the current Bottom-of-the-Pyramid (BOP) innovation debate (Prahalad & Hammond 2002; Prahalad 2005; 2006).

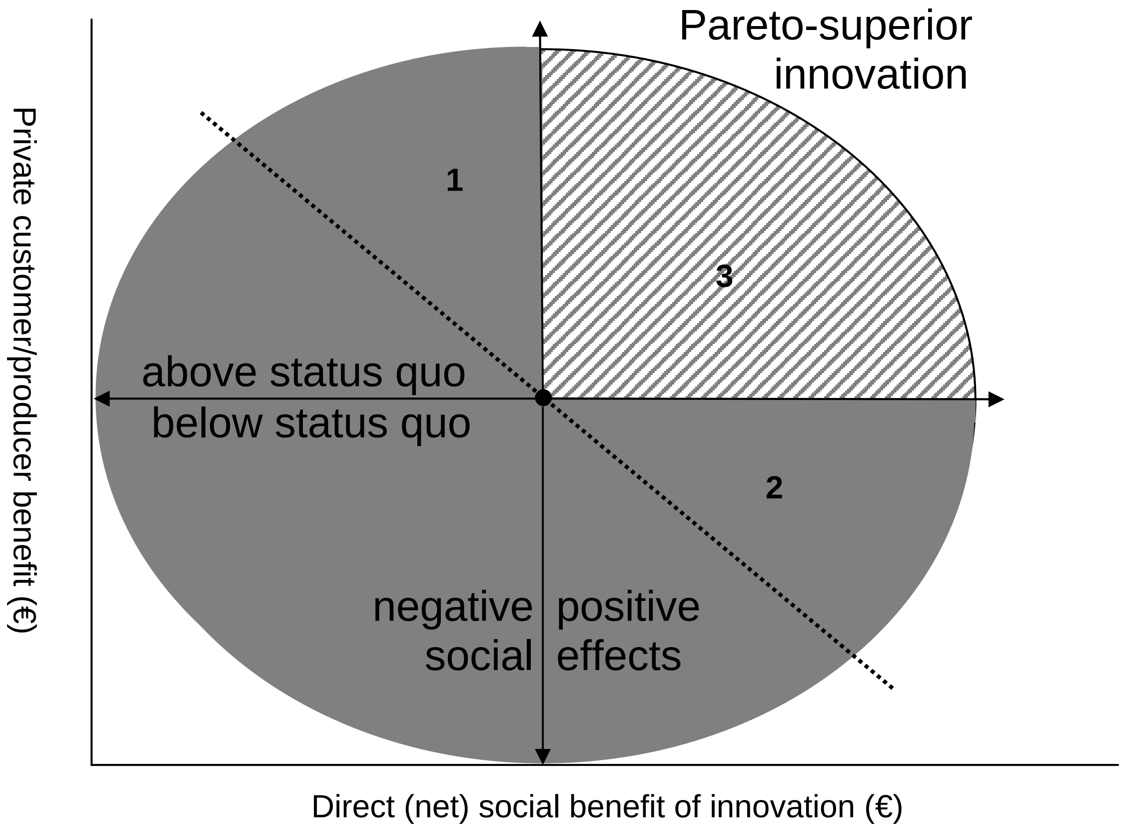
In this sense, one can conceptualise sustainability is a bundle of public goods (intra- and intergenerative equity, improvement or preservation of environmental quality, protection of human health and innovation is one key approach to preserve these public goods. For example, Fichter (2005, 84-87; 371-373) distinguishes five types of sustainability strategies and identifies amongst these the innovation-based strategy as the one which can contribute most to sustainable development. At the same time he argues that the innovation strategy enables private benefits to firms by creating new markets and market segments.

Because of this conceptual prominence for sustainable development, sustainability aspects in innovation processes have received increased intention of policy makers, particularly stressing the role of industrialised countries as lead users and lead markets in areas such as sustainable energy technologies, products based on bio-materials or nanotechnology and recycling processes. In order to enable a more specific analysis, the term sustainability-related innovation shall be defined more precisely. Hauschildt (2004) distinguishes generally three categories he proposes to measure innovation success, namely (direct or indirect) technical effects, (direct or indirect) economic effects and other effects. He explicitly refers to environmental and social effects as specific subcategories of other effects. Hauschildt and Salomo (2005) address interactions of different factors with the degree or level of innovation and based on their reasoning, one can derive, that sustainability-related innovations have a high degree or level of innovation since in their case the environmental and social effects are intended, i.e. represent additional demands.

However, it is based on this reasoning a very valid question whether sustainability-related innovation is a special type of innovation in a qualitative sense, or just "better managed innovation", i.e. innovation, where more target criteria are integrated and made mutually compatible. Such innovation would in this sense only be a quantitative extension of the above performance categories of innovation success, rather than a qualitatively new form of innovation.

The following Figure 1 conceptualises and defines further sustainability innovation in a more general way. It illustrates, that the private benefit of an innovation (i.e. the cost reduction the innovation brings about for e.g. producing a good whilst keeping the benefit of that good constant) is relevant for sustainability innovation, too. This is because the higher the private benefit, the higher is the potential of an innovation to compensate for negative social effects of that innovation (e.g. because it implies a high level of resource consumption). Assume the grey and dashed-grey area in Figure 2 (i.e. the full circle) is the set of all possible innovations. If social benefit and private benefit of an innovation can be monetarised in a way that both axes of Figure 1 have the same scale, then conceptually, all innovations below the dashed line running from the upper left to the bottom right are not sustainable in that either they have both, negative social effects and low private benefit, or their compensation potential due to the (lacking) private benefit is so low that it cannot compensate fully for the increased resource use. This can be termed the "Playstation World" of innovations based on the notion, that such innovations neither provide positive social effects, nor do they meet consumer demand at a cost so much lower, that the consumer could at least in principle compensate society with his consumer surplus for the negative social effect. The areas denoted (1) and (2) in Figure 1 represent innovations that are (1) sufficiently economically radical to compensate negative social effects or (2) where the positive social effect would justify to society to accept a lower level of private benefit (i.e. reduced consumer surplus) because the total benefit (i.e. the increase of consumer surplus through e.g. price reductions plus the monetarised positive social benefit) to society would remain unchanged. Innovations in areas (1) and (2) could thus be termed compensatory sustainability innovations. Finally, those innovations in areas (3) of Figure 1 (represented by the dashed-grey quarter of the circle) are those that are Pareto-superior, that is if technologies or innovation opportunities exist in areas (1) and (3) with the same level of private benefit then the latter are to be preferred from a societal point of view. Innovations in areas (2) and (3) of Figure 2 are what is traditionally understood as a sustainability innovation (or, more specifically, if the positive direct social effect refers to a reduced environmental externality, an environmental or eco-innovation). This distinction is related, but not identical with the concept of Ilinitch and Schaltegger (1995) of eco-efficiency portfolios.

FIGURE 1: Link between economic radicality and direct social benefit of an innovation



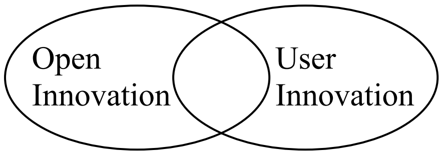
Innovation cooperation and open innovation for sustainability-related innovation

Co-operation (e.g. in terms of innovation networks, acquisition of innovation, open innovation or user innovation) seems to be relevant for sustainability-related innovation to the degree that such innovation is technologically radical and complex i.e. requiring the involvement of a large number of actors or capabilities and having significant technological, economical and company-specific uncertainties which require the bundling of different resources and competencies (Karl & Möller, 2004). To achieve a large improvement, sustainability-related innovation requires complementary changes to enable the most suitable uses and a large range of usage possibilities are needed (Konrad & Nill 2001: 37). The German Environmental Protection Agency e.g. states in this respect:

“*Technische Effizienzverbesserungen stoßen an Grenzen, die ohne eine Veränderung der bestehenden ökonomischen, rechtlichen und gesellschaftlichen Rahmenbedingungen nicht überwunden werden können. Zusätzliche Emissionsminderungen, Ressourceneinsparungen und Naturschutzverbesserungen, die über die oben beschriebenen technischen Umweltentlastungspotentiale hinausgehen, setzen vor allem die Bereitschaft der Gesellschaft zu Veränderungen vertrauter Strukturen und Wertvorstellungen voraus* (UBA 1997: 163)“. This statement illustrates that technological and organisational changes often do not suffice, but that changes in market and agent relations are necessary. Some of these resources or competencies are not accessible through markets, and may therefore require cooperation or even acquisitions (Karl & Möller 2004). Also sustainability-related innovation processes tend to be socially very complex, and the knowledge to implement the innovation is widely distributed and that because of this only a very small amount of the overall knowledge needed to carry out the innovation is available in any single firm. Boons and Roome (2005) therefore stress the role of innovation networks (see also Gemünden et al. (1996) for important variations with regard to innovation network configuration) and de Bruijn and Tukker (2002) point to the role of partnerships for sustainability-related innovation whilst Starik and Rands (1995) point to the role of inter-organisational cooperation. Another remedy to the challenge of distributed knowledge are distributed search processes based e.g. on open innovation processes und user innovation carried out by lead users as for example the case of the Novartis foundation.

Open innovation and user innovation are discussed in this paper with respect to one specific context, namely how they related (and can ideally contribute) to the sustainable development (i.e. increased sustainability) of corporations and societies. Open innovation and user innovation are (as will be argued later, partly related) phenomena much debated recently in academic communities and by business practitioners and it seems to be particularly relevant in the context of sustainability innovation as we will illustrate below. It has been linked to work in the field of experimental economics with regard to the observation of reciprocial behaviour between economic agents referred to as reciprocity (e.g. Fehr & Schmidt, 1999; Bolton & Ockenfels, 2000) and the social welfare implications of processes of open innovation or user innovation (e.g. Harhoff et al., 2003). Reciprocity has received special attention as concerns the open source software movement, as one example of an open innovation process. Open source software (OSS) also illustrates, that open innovation is not the same as user innovation, but that the two concepts are closely related. For example, some OSS developers (such as Linus Thorvalds when writin the Linux code and making it available freely on the internet) are users and hence the freely revealing of their innovation is both, a process of open innovation as well as an user innovation (possibly because Thorvalds was a lead user, i.e. somebody who was in particularly high need of an innovation that also foreshadowed a large future demand).Other agents, such as IBM when downloading OSS and integrating it into its own products (as in the case of their Apache Server software) can only benefit from this open (i.e. freely revealed) innovation if the company sells the product in which the open innovation, i.e. the piece of OSS. This need would imply that IBM is in this case no user innovator but a manufacturer innovator. However, the rules of OSS would still imply that IBM has to reveal some part of its innovation and in this sense takes part in a process of open innovation. This relationship between open and user innovation, which is illustrated in Figure 2 means that there is an intersection of innovation processes, that are both user and open (i.e. freely revealed) innovation (see also Harhoff et al. (2003) on this aspect), that there are innovation processes that are either open or user innovation and that there are processes that are neither of the two. Nevertheless, the theoretical possibility of a joint occurrence of user and open innovation justifies an integrated treatment of the two in this paper, especially in the context of environmentally- and sustainability-related innovation cooperation.

FIGURE 2: The relationship between open and user innovation



One question that may arise is whether sustainability-related or environmental innovation is a specific type of innovation that lends itself to user innovation or open innovation processes (e.g. in case it requires a significant inventive step (as defined in Hauschildt & Salomo, 2005), is technologically radical and/or is complex requiring the coordination of a high number of agents or actors)?

As concerns user innovation in this respect, sustainability-related innovation is by definition characterised by proportionally higher social benefits for users (from reduction of negative externalities) relative to private benefits that accrue to manufacturers. Also sustainability-related innovation, at least for some user groups implies considerable immaterial benefits (in terms of e.g. increased happiness of "doing the right thing", i.e. a "feel good" factor relating to moral satisfaction). This should lead to higher incentives to innovate for those users benefiting from reduction of negative externalities and immaterial aspects than for manufacturers and should result in increased user innovation activity. A specific example that illustrates such sustainability-related user innovation is that of Deutsche Bahn AG with regard to car sharing. Car sharing systems initially originated amongst users and were thus a user innovation (Hockerts, 2003). Deutsche Bahn as a manufacturer innovator and large incumbent firm started later than these users to offer car sharing and essentially took over manufacturing from some of the initial user innovators who were motivated at least partly by immaterial factors. This transition is in its general features analysed by Baldwin et al. (2006) who point out the crucial role of user communities for the transfer from user innovator to manufacturer innovator. The acquisition of user innovators by a late-entrant manufacturer is a special case of the acquisition of sustainability-related innovation for which other examples are the acquisition of Body Shop by L´Oreal or of Ben & Jerry's by Unilever. These latter two examples fit the open innovation paradigm, where the acquisition of strategic resources is one extreme on a continuum between make or buy decisions. Strategic resources are (next to product lines that allow differentiation in a new dimension or improve a manufacturers corporate image) also those that are complementary to a manufacturer's core product and where manufacturers, instead of acquiring may opt for innovation cooperation initially. Whereas for user innovators it may be preferable to ultimately hand over production to a manufacturer innovator, the example of Hamburg Airport shows, that sustainability-related user innovation may also remain within a (commercial) user innovator as a new area of business. In this case Hamburg Airport, leveraged its knowledge in noise protection gained from application to its own operations which require high levels of noise protection as an almost inner-city airport (also involving different user innovations such as demand side measures to reducing flight noise impacts for local residents) by selling it as a service (i.e. acting as a manufacturer innovator) to other regional airports.

Defining a business case for sustainability-related innovation

A key requirement for spontaneous emergence seems to be the existence of a business case, i.e. a demand side that enables profitable sustainability innovation (see Schaltegger and Wagner (2006) and Schaltegger and Synnestvedt (2002) as well as Wagner and Schaltegger (2003) for the fundamental logic behind a business case for sustainability).

Hence the existence of a business case for a sustainability innovation implies that the willingness to pay (WTP) in the relevant market is sufficiently high for the product or process innovation in question. A situation in which no business case exists could be caused by the lack of a willingness to pay for an innovation that brings about social benefits, e.g. in terms of reduced environmental externalities. If no business case exists, e.g. because of low WTP the state could intervene in order to regulate market failure if the sustainability innovation in question represents a high social benefit, i.e. if the level of internalisation of the external effect (e.g. through taxes or certificate systems) is low.

The earlier example of Deutsche Bahn AG seems to be a very telling case since they integrated it into its offerings based on a business case and in a way that ensured it would not jeopardize its profitability. More generally, one can even ask the question whether logically, there can be a case beyond the business case. For example, as concerns environmental innovation as a special case of sustainability-related innovation, there seem to be five possible reasons as to why a firm would pursue them. Firstly, this is because new legal requirements can only be met by means of the innovation, in which case it would be the example of a regulation-driven innovation (of course in a way different to Porter's notion of regulation triggering a win-win situation in that it could be that the net benefit of the innovation to the firm could be negative, but still it is needed to continue operations, i.e. the innovation is driven by a business case, since without it the firm had to shut down).

Secondly, firms could enable cost reductions through the innovation which would be a production-related benefit leading to increased profitability. Thirdly, the innovation could increase product quality, which would be a market-related benefit enabling higher unit prices at constant cost, again improving profitability. Fourthly, carrying out the innovation could improve the corporate image which at least in principle could lead to a market-related benefit in that heightened positive attention increases the firm's sales quantity and hence overall profits (at constant profit margin). Finally, an innovation could be pursued out of completely altruistic means, that is, no short- or long-term economic benefit would result from carrying out the innovation which would hence be beyond any (even enlightened) self-interest of firms. Only in this last case, one would be faced with a case beyond the business case.

One can also model these considerations in a two-stage game where on the first stage a new legal requirement is introduced that causes increased demands as concerns the characteristics of production processes or products. In this situation, firms have the choice between purely complying with the new demands, or going beyond compliance. The latter is the more rational, all else being equal,

- the higher the reduction of the variable production cost is, that results from the innovation,
- the higher the improvement of production quality stemming from the innovation (as long as a positive WTP for this improvement exists),
- and the higher the effect of a reputation improvement on the sales quantity or maintaining the license to operate after the innovation

of the adoption of a technology or organisational change going beyond pure compliance. Of course, a reputation improvement without any effect on sales quantity or license to operate would be altruistic, but the influence of an improved reputation on sales could be very indirect or long term.

An interesting aspect at this point is whether end-of-pipe or integrated technologies are equally suitable to go beyond compliance. It seems that technologically, this is well feasible, but that the evaluation on the different elements of a business case differ as laid out in the following Table 1 which is based on the assumption, that both types of technology achieve the same improvement beyond compliance.

TABLE 1: Comparison of end-of-pipe and integrated technologies for the business case

Technology	License to operate	Sales quantity (reputation)	Product quality	(variable) production cost
End-of-pipe	+	+	O	O / -
Integrated	++	++	O / +	+ / ++

As can be seen, as concerns the license to operate and any effect on sales quantity resulting from a reputation enhancement (controlling for all other simultaneous effects on sales quantity), choosing an integrated technology for going beyond compliance dominates end-of-pipe technologies. Per definition, an end-of-pipe technology has no effect on the production process and cannot hence change product quality nor reduce production cost. It could however (also per definition) lead to additional (unit) production cost.

Depending on the decision of the firm on the first stage of the 2-stage game described above, a differing behaviour of the firm on the second stage can be observed. For example, if a firm chose on the first stage to be just compliant, it could on the second sage then choose to adopt an end-of-pipe technology which has higher running cost in the long term (compared to adopting an integrated technology), but my have lower investment cost and minimises interference with production processes (i.e. no modification of production processes is needed). In specific market situations (e.g. periods of high demand) or plant conditions (e.g. a plant being scheduled already to cease operations at a defined point in time in the future) this may be the rational decision.

On the other hand, if an innovation aims to go beyond compliance then the adoption of an integrated technology may be the rational decision, if it implies a strong reduction in (variable) production cost or a sufficiently high improvement of product quality or sales quantity from the reputation effect of adopting that technology. However, an integrated technology (which e.g. could reduce production cost through process change) may also be appropriate to become just compliant. In such a case, it would be simultaneously possible to achieve compliance and reduce cost and it could also at the same time be feasible to achieve reputation gains or to improve product quality.

Yet, there is likely a trade-off between these different objectives. For example the more a firm moves towards pure compliance the less likely and strong are reputation gains. Conversely, the more an innovation (such as an integrated technology) is motivated by altruism the higher should be the reputation enhancement. On the other hand if the reputation improvement is high because the firm acts altruistically in the first place and if this leads to higher sales quantities, then this would imply an economic benefit and hence the behaviour of the firm could not be termed altruistic any more. The same is the case if an altruistically introduced integrated technology subsequently reduces production cost unintentionally, or else, improves product quality. In both cases, the firm reaps economic benefits which render the initially altruistic intention obsolete. This is what I term the paradox of a case beyond the business case: if the firm acts completely altruistic, then realises unavoidably other objectives (such as reputation enhancement) which ultimately lead to economic benefits which render the initial altruistic intention obsolete. Hence, because different innovation motivations as outlined in the beginning of this section interact unavoidably with one another, they are not separable and hence a case beyond business case in principle not feasible.

Research questions

In the end, given the definition of a sustainability-related innovation provided in the first section it does however not matter from whether firms pursue sustainability-related innovations for profit or not (i.e. whether they pursue a business case or go beyond it as long as the extraordinary environmental or social benefit can be objectively measured and verified. What is however interesting, especially in light of the second section on cooperation and openness is, what capabilities in the company bring about sustainability-related innovation. Empirically, it is observable, that some firms realise more sustainability-related innovations than others and next to context factors which need to be controlled for, the most likely explanatory factor are certain activities or capabilities that some firms have and others lack (e.g. Schaltegger, 2002). Hence two main research questions here is about the association of EMS and CSR with environmentally and socially (particularly) beneficial innovation:

Research question 1: What is the link of EMS with environmental particularly beneficial innovation?

Research question 2: What is the link of corporate sustainability performance with sustainability-related innovation?

Next to capabilities as reflected in CSR or environmental management activities, also structural factors may differ between firms. One important structural factor related to the role of individual families in the management and ownership of firms. For example, Dyer and Whetten (2006) report that family firms pursue significantly fewer concerning (i.e. negative) activities regarding social responsibility than non-family firms. This supports the notion that family owners are more concerned about positive reputation. Yet, the study also finds, that family firms do not pursue significantly more proactive (i.e. positive) CSR or environmental management activities. Still, indicating a possibly higher awareness and activity of family firms with regard to corporate sustainability, Uhlaner et al. (2004) find that inclusion of the family surname in firm name increases perceived social responsibility. However this may reflect more stakeholder beliefs about family firms than actual differences to family firms. Still, it has been argued that family firms have a more long-term orientation which could lead to more sustainability management activities and ultimately higher sustainability performance (Anderson & Reeb, 2003). Block (2008) finds that family firms tend to pursue less severe employee downsizing compared to non-family firms. It has also been found, that the association of environmental management activities with innovation is more strongly positive in family firms (Craig & Dibrell, 2006) Hence, another important research question is:

Research question 3: Is there a moderating effect of being a family firm on the link between corporate sustainability performance or environmental management with sustainability-related or environmental innovation?

EMPIRICAL ANALYSIS

The empirical analysis of the research questions derived in the previous section uses panel data for a set of U.S. firms. The advantage of panel data is that unobserved heterogeneity is not a problem, since panel estimation techniques largely capture its effects. Furthermore, using panel data enables the inclusion of lagged values, which reduces endogeneity problems and issues regarding assumed directions of causality that arise from contemporary independent and independent variables.

The set of firms in the Standard & Poor's 500 index as of 31 July, 2003 was used to define the sample of firms to be analysed. This point in time was chosen since BusinessWeek provides a full list of which of the S&P 500 firms of that date are family firms (Anon., 2003) and also provides data on ownership structure and board composition and management roles for the family firms identified. The remaining non-family S&P 500 firms in the index are identified from the KLD data and from the S&P website (S&P, 2007).

The main sources from which data was collected were the Compustat and Worldscope Disclosure and BankerOne databases and the ratings of corporate social responsibility and environmental management carried out by Kinder Lydenberg Domini Inc. (KLD). The KLD database contains detailed annual ratings on the environmental and social activities and performance of over 600 of the largest U.S. companies. The data is available for a period of over ten years and enables a detailed assessment of firms' activities with regard to the environment and to social issues. It is also one of the most reputed sources for scholarly studies in the field of stakeholder management (see Waddock& Graves 1997; McWilliams & Siegel 2000). After matching KLD data with financial and ownership/management data from the other sources 3697 usable cases remained for the period 1993 to 2003, for which data was however not always available on all variables included in the analysis.

As concerns the dependent variables measuring innovation, KLD data allows to construct three meaningful binary indicators. These three (binary) dependent variables (addressing essentially product innovation) are firstly environmental Innovation as defined by KLD in ist variable ENV-str-A. This variable indicates that a firm has introduced products or services which protect the environment or is achieving significant sales with such products or services.

Secondly, a binary measure for CSR innovation was derived based on the KLD variables PRO-str-C and PRO-str-X. A firms was assigned a value of 1 on the CSR innovation, if it had a positive rating on either one or both of these variables for the year in question, and 0 else. PRO-str-C is a KLD variable that records whether part of a firm's mission is the provision of products or services for the economically disadvantaged, PRO-str-X a variable measuring whether a firm's products have notable social benefits that are highly unusual or unique for its industry.

Finally, a variable measuring sustainability Innovation is used, that is based on the two other variables. It reflects whether a firm carries out environmental or CSR innovation, or both.

Based on the KLD raw data, four indices were constructed. This was firstly a narrow EMS index, comprised of the KLD variables Env-str-B; C; D; X; Env-con-A; B and in a variant from 1996 on also Env-Str-E (which was later recoded as CGOV-str-D in the KLD data). This narrow EMS index ranges from 1 to 5 and 6 (in the case of the variant with one additional variable).

Secondly, a wider environmental management index comprising ENV-str-B; C; D; X; ENV_con-A; B; C; D; E; X; CGOV-str-D; COM-con-B; EMP-con-B; EMP-str-E; PRO-con-A; X was calculated, for which index values could range from 1 to 16. However, empirically they only range from 2 to 14 with a mean of 7.0.

Thirdly, a corporate social responsibility (CSR) index comprised of the KLD variables COM-str-A; B; C; COM-con-A; DIV-str-A; B; C; D; E; F; DIV-con-A; B; EMP-str-A; C; D; F; EMP-con-A; C; D was calculated, which referred to social issues and activities only which could however address the demands of internal as well as external stakeholder groups. The index can range from 1 to 19, but does in practice only range from 3 to 15. Its mean value is 9.5.

Fourthly and finally, an overall corporate sustainability index was calculated that comprising all KLD strengths and concerns that were available for all years from 1992 through to 1993. This index is identical with the one used by Dyer and Whetten (2006) who also provide more descriptive details on the index. This last index essentially measures the totality and hence the extent of all activities related to corporate sustainability (positive or negative) and it can thus be understood as a measure of overall sustainability performance of a firm for a given year. The index ranges from 0 to 19 with a mean value of 10.1. It was considered to instrumentalise the environmental, CSR and sustainability performance measures with data on important regulatory changes in order to improve the quality of the estimate. However, all significant regulation that could have triggered an increase in the level of disclosure or external assessment of the firms social and environmental management activities took place before 1993. Hence an instrumental variables approach was not pursued further in this respect.

Next to the core dependent and independent variables, a number of control variables have been included. These include firm size and also in some variants the square of firm size as suggested in Hemmelskamp (1999). As the distribution of some variables, such as firm size was highly skewed, logarithmic values of these were used in the empirical analysis.

Also R&D intensity measured as R&D expenditure divided by sales and (real) GDP growth as a proxy for demand conditions as suggested in Horbach (2008) were included in the analysis. Also Tobin's Q as a control for firm performance and market valuation and a variable measuring if a firm has a quality management system are included as control variables. All explanatory variables introduced so are lagged behind by one year (i.e. are for t-1) in the analysis to avoid problems of endogeneity.

Industry membership as measured in eight different SIC industry categories, as well as time dummies for each year in the data (1992 – 2003) were introduced as non-time-lagged variables.

Finally the variable described earlier capturing whether or not a firm is a family firm based on BusinessWeek (2003) was included in the model to address the third research question, jointly with an interaction term of this variable with the overall corporate sustainability index is included.

Fixed and random effects panel models according to the following equation are estimated in the following:

$$y_{it} = \alpha + \vec{\beta} \cdot \vec{x}_{it} + \vec{\gamma} \cdot \vec{z}_i + u_{it} \qquad (1)$$

In (1) *i* equalling 1 to N refers to the units under observation and *t* equalling 1 to T refers to the time periods in the data (1992 to 2003). y_{it} are the binary innovation dependent variables for firm i in period t. x_{it} is the vector of time-variant regressors and z_i the vector of time-invariant regressors (the industry and year dummies). The Hausman test is used to ascertain that RE model is appropriate

RESULTS

As concerns the first research question on the link of environmental innovation and environmental management, Table 1 shows that no significant association exists. Also, when analysing the possibility of reverse causality as has been suggested by Seijas-Nogareda and Ziegler (2007), even though the association between management and innovation is significantly negative, this is not consistent with the theoretically expected direction of reversed causality. These results did not change in the light of extended sensitivity analysis, involving e.g. additional explanatory variables (Tobins's Q, sales growth, a dummy for being a family firm, a dummy existence of a quality management system (QMS), a dummy for missing data on R&D intensity and whether the firm is extraordinary R&D active as measured by the KLD variable KLD-Pro-D) and different specifications of model (including e.g. the squared term of logarithm of sales, normalisation of the EMS index score relative to logarithm of assets, usage of dummies for each level of EMS implementation instead of an index and interaction terms of a firm being a family firm with environmental management and the CSR index). When not limiting the sample to only the R&D intensive sectors in the sample (SICs 28, 35-38, 73) or only the period after 1996 (for which the EMS-Index could be expanded by an additional variable measuring environmental reporting and transparency) also the results as concerns the main variables environmental innovation and environ-mental management did not change in both variants of the model reported in Table 1.

A similar exercise was carried out for the social innovation variable and the CSR index (both as defined above) which involved almost identical sensitivity analysis as described for the environmental variables, but the results showed again no significant association between innovation and management.

TABLE 2: Quantitative link of environmental innovation and environmental management for R&D intensive sectors

Explanatory variables and fit statistics	Dependent variable of random effects models (binary and ordinal logistic regression) is …	
	environmental innovation	Level of EMS implementation
Log. Sales (USD) in t-1	0.14 (0.30)	-0.17 (0.09)*
R&D quota (%) in t-1	-196.33 (68.32)***	4.88 (6.24)
Level of EMS implementation (5-point Scale, 0: no actitivites) in t-1	-0.32 (0.34)	-
ENV-str-A (environmental innovation) in t-1	-	-0.82 (0.23)***
Constant	-28.59 (4957.39)	-6.85 (2.06)***

Number of observations (minimum/ mean/maximum number per firm)	1133 (1/7.4/11)	
Log likelihood	-146.63	-713.69
Rho	0.77	0.67
Likelihood ratio χ^2-test	363.07***	17.87***
Hausman test (χ^2)	9.38	-

*: weakly significant (10%), **: significant (5%), ***: highly significant (1%)

Concerning the second research question on the link of corporate sustainability performance and sustainability innovation, Table 3 shows, that a significant positive association is found indicating that sustainability management activities could drive sustainability innovation.

TABLE 3: Quantitative link of sustainability innovation and sustainability management

Explanatory variables and fit statistics for random effects model	Dependent variable: sustainability innovation
Log. Sales (USD) in t-1	1,71 (5,43)
Square log. Sales (USD) in t-1	-0.04 (0.12)
R&D quota (%) in t-1	-17.67 (35.75)
Corporate Sustainability Performance in t-1	0.18 (0.08)**
GDP growth in t-1	-0.28 (0.16)*
Tobin‘s Q in t-1	-0.16 (2.65)
QMS in t-1	1.11 (0.58)*
Constant	-27.98 (61.09)

χ^2-test for joint significance of industry dummy variables	2.00
χ^2-test for joint significance of year dummy variables	7.73
Number of observations (minimum/mean/ maximum number per firm), number of firms	1759 (1/7/11), 252
Log likelihood	-259.99
Rho	0.76
Likelihood ratio χ^2-test	510.5***
Hausman test (χ^2)	17.74

*: weakly significant (10%), **: significant (5%), ***: highly significant (1%)

Concerning the third research question, being a family firm has an effect on how sustainability management associates with sustainability innovation, as can be seen in Table 4. From that table it becomes clear, that whilst being a family firm per se has a negative effect on sustainability innovation, family firms with high sustainability performance carry out over-proportionally often sustainability innovation.

TABLE 4: Quantitative link of sustainability innovation and sustainability management taking into account the effect of family firms

Explanatory variables and fit statistics for random effects model	Dependent variable: sustainability innovation
Log. Sales (USD) in t-1	1.49 (5.57)
Square log. Sales (USD) in t-1	-0.03 (0.12)

R&D quota (%) in t-1	-14,73 (33,76)
Corporate Sustainability Performance in t-1	0,03 (0,10)
GDP growth in t-1	-0.31 (0.16)*
Tobin‘s Q in t-1	-0.18 (0.15)
QMS in t-1	1.03 (0.59)*
Family Firm (1=yes; 0=no) in t-1	-5.68 (2.09)***
Family Firm * Corporate Sustainability Performance in t-1	0.54 (0.18)***
Constant	-23.67 (62.48)
χ^2-test for joint significance of industry dummy variables	1.70
χ^2-test for joint significance of year dummy variables	7.86
Number of observations (minimum/mean/ maximum number per firm), number of firms	1759 (1/7/11), 252
Log likelihood / Rho	-256,15 / 0.76
Likelihood ratio χ^2-test	486.39***
Hausman test (χ^2)	18.51

*: weakly significant (10%), **: significant (5%), ***: highly significant (1%)

CONCLUSIONS

The analysis reported here was aimed at addressing the factors that bring about sustainability innovation in corporations. Whilst whether or not this is because firms aim to realise private benefits and attempt to maximise profits is of secondary importance as explained earlier. What is of more relevance is why there is heterogeneity across firms in the capability to pursue sustainability innovation and hence what underlying capabilities are crucial to realise sustainability innovation.

The analysis in this respect finds no association of environmental management with environmental innovation. This insignificance of the association between EMS implementation levels and environmental innovation remains unchanged in an extended sensitivity analysis. As Table 2 shows, the environmental innovation activities of S&P 500 firms in six research-intensive industries seem to be mainly determined by total R&D intensity. Hence, the theoretically justifiable link of EMS and environmental innovation cannot be detected in the data. This fits however with earlier survey research (Wagner 2007; 2008) in which no significant association of EMS with environmental product innovation was found, because the latter is essentially what is measured with the KLD variables used. The results leave open the option, that causality is reversed, however, the theoretical arguments for this are weak (Wagner, 2007). Another explanation could, that the innovation measure used is weak. This certainly is to a degree the case, but better measures were not available. Ideally one would like to have data patents for all the firms in the sample which would enable an identification of environmental patents (as a more narrow and precise measure of environmental innovation) based on a combination of keyword identifiers and IPC identifiers. However, such a measure has other limitations such as not addressing the commercial success of an invention. Again, this could be, at least partly, rectified by incorporating patent citations in the analysis.

In the more recent and wider context of sustainability, a significant positive association is found between innovation and performance and the underlying management activities. This positive link is however moderated by whether or not a firm is a family firm. These findings are consistent with both, Dyer and Whetten (2006) as well as Craig and Dibrell (2006). As concerns the former, the findings confirm that being a family firm per se does not have a positive effect on actions that are beneficial for sustainability. As concerns the latter, the insignificant effect of management activities on innovation for non-family firms is confirmed. Notably, in all models, the industry and year dummies are never significant.

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