Eco-Entrepreneurship – An Empirical Perspective based on Survey Data

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Abstract

Eco-entrepreneurship has become an increasingly researched area, not least because it increasingly caught the attention of policy makers as one promising response to sustainable development challenges. Given the emerging character of the field, to date however most contributions remained conceptual or reported results of case study research. The discussion of eco-entrepreneurship should therefore benefit from the analysis of large-scale empirical research projects. This chapter contributes to a large scale empirical analysis at both, the individual and the firm level. At the individual level, eco-entrepreneurship seems to crucially depend on environmentally-concerned individuals actually behaving entrepreneurially. Despite this being a crucial pre-condition, its empirical validity has rarely been analysed. I use large-scale survey data to answer the question of how environmental concern and entrepreneurial behaviour are related. At the firm level, numerous classifications of eco-entrepreneurial ventures have been provided at the conceptual level. I extend this literature at this level, by analyzing for a large-scale sample of European firms what determines their classification into being a specific category of an eco-entrepreneurial venture.

Introduction

Eco-entrepreneurship has emerged as an intensively debated topic over the last years with a recent upsurge of writing in the field. At the same time, the debate on this topic has moved increasingly from journals focussed on environmental management (e.g. Schaltegger 2002) to mainstream business journals (e.g. Cohen & Winn 2007; Dean & McMullen 2007). The topic of eco-entrepreneurship lies at the nexus of innovation, concern for the environment and entrepreneurship. Yet, to date most contributions remain conceptual or focus on reporting case studies (e.g. Schaltegger 2002; Schaltegger & Petersen 2001). Rarely found are results and analyses of larger-scale empirical surveys on the topic and it is this gap in the literature that this chapter addresses. More specifically, at the individual level I analyse the linkages between entrepreneurial behaviour and environmental concerns and at the firm level I study what predicts the classification of a venture into a specific category of eco-entrepreneurship in order to arrive at a better understanding of the value of conceptual models of eco-entrepreneurship. Based on data collected among students and alumni from science and engineering programs of a large German technical university, I apply binary choice models and provide a nuanced empirical answer to this question. At the firm level, only few of these concepts have been applied to large-scale empirical data and even less so beyond mere descriptive analysis. Using important determinants derived from extant literature on entrepreneurship and innovation management, I apply ordered logit models to establish how these determine the categorization of an eco-entrepreneurial venture in the well-known scheme developed by Schaltegger and Petersen.

Extant Literature

Several definitions have emerged for what eco-entrepreneurship is. For example, some authors proposed typologies of eco-entrepreneurship. For example, Isaak (1999) distinguishes incumbent firms which become incrementally or stepwise more environmentally concerned

and entrants which from the start provide environmentally-benign products and use environmentally-friendly processes. Similarly, Schaltegger and Petersen (2001) and Schaltegger (2002) distinguish eco-entrepreneurship from other forms of corporate environmental management activities and summarize this with a positioning matrix. More recent attempts related eco-entrepreneurship to market imperfections and in doing so provided a more systematic categorisation of entrepreneurial opportunities that simultaneously contribute to environmental improvements, in essence arguing that specific market failures are the underlying root cause for such entrepreneurial activities (Cohen and Winn 2007; Dean and McMullen 2007; Cohen *et al* 2007).[1] What is notable in all these classifications as well as others (e.g. Linnanen 2002; Walley & Taylor 2002) is however the absence of the dimension of innovativeness (e.g. radical versus incremental or original versus imitation) which seems to be of considerable relevance for entrepreneurial rents as well as opportunity realization. Whilst from the review of extant it becomes clear that the field of eco-entrepreneurship over time has been growing quantitatively, that papers relating to it have been published more frequently in mainstream business journals and that the field as a whole has become more accommodating qualitatively, it still has not fully integrated the extensive literature on conventional entrepreneurship. In particular, a large theoretical, conceptual and empirical literature exists on the factors that determine entrepreneurial behaviour at the individual level (such as attitudes or education) as well as the firm level (such as industry conditions or firm size). It is this literature I link my large-scale quantitative studies of eco-entrepreneurship to.

Hypothesis development

Hypotheses at the level of the individual

As emerges from the review of literature, eco-entrepreneurship holds a bold promise, namely,

[1] It needs to be acknowledged though, that already Isaak (1999) and Pastakia (1998) mention the reduction of negative (environmental) externalities as a defining criterion for environmentally oriented entrepreneurship. Schaltegger and Wagner (2008) link this to an evaluation of the innovativeness of the opportunities pursued.

that because entrepreneurial opportunities exist which are caused by market imperfections, individuals will pursue these in the expectation of entrepreneurial rents. However, the literature also points us to assume that entrepreneurially minded individuals will pursue those opportunities from which they expect the highest rents to be extractable. The question immediately arises, whether the entrepreneurial opportunities that are based on market imperfections are identical with those that promise the highest entrepreneurial rents. One could argue that given the large number of market imperfections still existing with regard to the environment, based on revealed preferences the answer is no. More specifically, this is also well documented with regard to defined environmental fields. For example, the case of energy efficiency is well researched and it has been shown there, how inefficiencies persist, even though their removal would be profitable – yet not profitable enough to be preferred in the light of other investment opportunities with higher returns (Jaffe & Stavins 1994; Sanstad & Howarth 1994).

This raises intriguing questions about the promise of eco-entrepreneurship: is it that there are individuals, that are innovative (i.e. commercialise rather radical inventions), entrepreneurial and environmentally concerned? And does being both innovative and environmentally concerned associate with a stronger entrepreneurial drive? If the answer of at least one of these two questions is no, then the promise of eco-entrepreneurship may be flawed or at least for the moment significantly limited, and government intervention (e.g. support to universities in terms of degree courses that provide entrepreneurial skills to environmentally concerned students) may be justified to create conditions more conducive to eco-entrepreneurship in quite the same fashion such government intervention is demanded for energy efficiency investments (e.g. in terms of energy efficiency standards for buildings).

Based on these considerations, I propose the following two hypotheses:

H1a: There will be a positive relationship between an individual's environmental concerns and actual entrepreneurial behaviour.

H1b: The positive relationship between an individual's environmental concerns and actual entrepreneurial behaviour will be moderated by the level of innovativeness.

Hypotheses at the firm level

As concerns new venture firms, based on the literature review, the question arises as to what the conditions are for spontaneous emergence of eco-entrepreneurship in terms larger or smaller firms addressing the mass market or a niche, respectively.

Schaltegger and Petersen (2001) and Schaltegger (2002) have developed a typology of eco-entrepreneurial activities by classifying the extent to which such an activity has large market influence and what priority environmental objectives have in the firm. Based on these two dimensions, they identify four types of such activities, namely the ecopreneur (high market influence and high priority of environmental objectives), the bioneer (high priority of objectives, but low market influence), and the environmental manager (high or low influence and low priority). The model hence implies that having a large market impact can be related to both, environmental management and ecopreneurship. It also suggests, that having strong environmental objectives can be related to both, bioneering and ecopreneurship. For example the analysis of Petersen (2002) finds that amongst 64 new, 46 can be traced back to start-ups whose foundation was related to an ecological objective and who Petersen (2003) considers as having emerged out of the green movement.This implies a significance of management systems and size for eco-entrepreneurship.

I hence propose the following hypotheses:

H2a: The size of the firm is positively associated with the likelihood of being classified as an ecopreneur (i.e. the smaller the firm, the lower the likelihood of being an ecopreneur).

H2b: A firm having an EMS is positively associated with the likelihood of being classified as an ecopreneur.

Additional aspects of relevance are industry and firm age effects. Based on a classification of the environmental impacts of industries (Butz & Plattner 1999) and the literature on the linkages between firm age and performance (e.g. Sutton 1997), the argument can be made that Firms in environmentally more intensive industries and older firms are less likely to achieve the level of ecopreneurship (Jackson & Clift 1998). Conversely for younger the latter is more likely, since environmental concerns in society are a rather recent concern which puts younger firms in a better position for developing capabilities to react to this challenge (Larson 2000). Therefore I propose:

H3a: The environmental impact of an industry is negatively associated with the likelihood of being classified as an ecopreneur (i.e. the higher the impact, the lower the likelihood).

H3b: The likelihood of being classified as an ecopreneur is significantly negatively associated with the age of a firm.

Data and variables

Data at the individual level

To empirically analyse eco-entrepreneurship at the individual level, students and alumni of science and engineering degree programmes at the Technical University of Munich (TUM), one of Germany's largest technical universities, were surveyed. TUM received excellence status in a federal, Germany-wide competition as one of only three technical universities in October 2006. A web-based online questionnaire was distributed to students of TUM through the mailing lists of a large number of courses. The responses received yielded a response rate of 14.4% which is adequate for this type of survey. TUM alumni of science and engineering degree programmes and were contacted by email and invited them to participate in the survey, yielding a response rate 14.7% was achieved which is also deemed satisfactory for this type of survey.[2]

[2] Due to missing values, sample sizes were 313 and 125 observations for students and alumni, respectively.

Given no established definition existed in the at the time of the survey (see however Shepherd *et al* 2009 for a very recent proposal), based on a synthesis of the literature (Costanza *et al* 1997, Leiserowitz *et al* 2006, Moxnes 2004; Owen & Videras 2006; Torgler & Garcia-Valinas 2007) I operationalise environmental concern by means of six items referring to environmental protection and social responsibility, rated on a 5-point scale ranging from not at all accurate to very accurate. These items essentially reflect underlying attitudes and convictions (Fishbein & Ajzen 1972) and hence provide a link between these and eco-entrepreneurial behaviour to be expected by the individual expressing them to a high degree. The six items "German firms should take an internationally leading role in the field of environmental protection", "Firms that are environmentally oriented have advantages in recruiting and retaining qualified employees", "The environmental performance of a company will in future be considered more and more by financial institutions", "Corporate social responsibility should be part of the foundations of each company", "I think that environmental problems are one of the biggest challenges for our society" and "I think that entrepreneurs and companies need to take over a larger social responsibility" were used and an index of environmental concern calculated based on them.

Perception of barriers and support factors for entrepreneurial activities a well as personal attitudes towards entrepreneurial activities were measured based on Lüthje and Franke (2003) who identified 10 items of particular salience and by means of confirmatory factor analysis establish that these can be divided in perceived support factors and perceived barriers for becoming self employed. These items are measured on a 5-point scale as described before. Given the already-established unidimensionality of the constructs indices for perceived barriers and support factors are created based on the items.

As concerns attitudes towards self-employment the items used in Lüthje and Franke (2003) were used (measured this with the scaling as before) and items constructed based on these

To measure an individual's propensity to innovate (i.e. originality), I recur the the well known Kirton-Adoption-Innovation (KAI) index **(**Kirton 1976; 2003; Marcati *et al* 2008; Bagozzi & Foxall 1995) in the abridged 13-item version normally used today (Foxall & Hackett 1992; Taylor 1989). Based on a factor analysis, the established three factors originality, efficiency and conformity could be identified and the first factor of the KAI index was used to operationalise individuals' propensity to innovate.

In addition to this, a number of demographic and control variables, such as age, whether the respondent's parents are or have been self employed, and the degree course studied by the respondent are incorporated in the analysis (Charney & Libecap 2003; Hisrich *et al* 2008).

Self-assessment and self-exclusion of responders may be a cause for distortions in the data set, in particular as concerns common method and response bias. Concerning common method bias, the unrotated factor solution of Harman's single-factor test yields 38 factors of which 21 had Eigenvalues larger than unity. The first three factors explain 7.1%, 5.0% and 4.6%, respectively whilst the remaining factors with Eigenvalues greater than unity explain between 0.02% and 3.8% of the variance in the data. This is strong evidence against the existence of one single or dominating factor accounting for most of the variance in the data. Furthermore, comparing the 10% earliest and latest respondents for both, students and alumni, it is found that for students only the environmental concern index of late respondents (averaging at 4.0) is significantly higher ($p<0.05$) than that of early respondents (3.6). Whilst this could be an indication, that early responents were more of the type that is relatively indifferent towards environmental issues, it is not a serious issue. This is because the difference implies that my analysis provides rather conservative results and is not distorted by the fact that only strongly environmentally-oriented individuals have responded to our questionniare. Also, the fact that both groups score rather high values on the index which do only differ by 0.4 in absolute terms shows, that we are equally not confronted with the opposite problem that only individuals with a very low concern about sustainability have

responded to the questionnaire. For the alumni sample, none of the mean values of the explanatory variables differ significantly between the first and last 10% of respondents. Therefore, since only on one occasion a significant difference could be identified it is safe to assume that the early and late respondents in both samples are not (especially in terms of their demographic characteristics) very different and a comparative analysis as carried out in the following does not cause issues in this respect. Beyond comparing early and late respondents, it was unfortunately not possible to assess representativeness since no data on the characteristics of non-respondents was available to compare with those of those individuals who responded to the survey. Separate correlational analysis for both, the alumni and the student sample does not reveal issues with multi-collinearity of individual variables.

Data at the firm level

To empirically analyse eco-entrepreneurship at the firm level primary data collection was combined with secondary data sources which rated firms according to the typology developed by Schaltegger and Petersen (2001) beyond those in the initial publication (Brix *et al* 2006, Reichhardt 2007; Weyrauch 2007; Desa & Kotha 2006). In addition to the classification of a firm in these publications as either an environmental manager, a bioneer or an ecopreneur, data was collected on each firm's size as measured by number of employees and the age of the firm (both at the time when the classification of the firm according to the typology took place). Furthermore, data was collected on the country in which the company was headquartered, the main industry it operated in and whether or not the company had a certified environmental management system either according to the European Union Eco-Management and Audit Scheme or according to the ISO 14001 standard. Firm size was subsequently classified in three categories according to the definition used by EUROSTAT, the official European Union statistics bureau (EIM 1997: 329). In this, small firms are defined as those with less than 50 employees, whilst medium-sized companies are considered

to be those in the range of 50-250 employees and large firms are defined as those having in excess of 250 employees. Country location of a firm (or its headquarter) jointly proxies for a number of influences. This can e.g. be the level of stringency of environmental regulations, the type of instruments used to implement these (e.g. economic instruments, or command-and-control legislation), which may have an influence on the efficiency of environmental regulation in different countries, or the level of general business taxes in the country. The joint influence of these factors is captured in the Environmental Sustainability Index rating of the country which is provided on a regular basis (WEF *et al* 2001; Esty & Porter 2001; Esty *et al* 2005). The index which is ranging between zero and 100 is a a more precise measure of the environmental concerns and pressures in a country than a dummy variable for country location. It is used in my analysis to control for the level of environmental sustainability concern in the different countries and hence the context in which a firm operates and which may partly determine its efforts with regard to the environment. The industry ratings for environmental impacts were transformed from a 5-point scale to four dummy variables (relative to an industry having no environmental impacts) which related to below-average, average, above-average and very high environmental impacts, respectively. The binary dummy variables are taking unity value, if a firm is located in the sector designated by the dummy variable and zero otherwise. This approach is superior over using an ordinal variable to represent the 5-point scale ranking.[3]

In total, 41 firms could be identified which have been rated according to the typology of Schaltegger and Petersen (2001) as being environmental managers, bioneers, or ecopreneurs. For all these firms, collection of additional information as described was possible. Of the 41 firms, 6 are categorized as environmental managers, 20 as bioneers and 15 as ecopreneurs. The age of the firm ranges between 5 and 140 years, and whereas 24 firms have an

[3] Only if all coefficients for these dummy variables would be found to have proportionally increasing or decreasing values, the use of one ordinal variable instead would be appropriate. Therefore, the use of dummy variables relaxes the assumptions made with regard to environmental impacts, i.e. this does not have to be a linear, stepwise increase but orders of magnitude could change between two adjacent categories/levels.

environmental management sstem, 17 do not. Of the firms, 11 can be categorized as small firms, seven as medium-sized and 23 as large firms.[4] As before, correlational analysis did not provide any indication, that multi-collinearity could be a problem in the analysis.

Models

As concerns econometric modelling, given the dependent variables of the analysis are binary and ordinal, binary and ordinal choice models are used (Greene 2003). The dependent variable in the binary probit model (Long 2002) with the data at the individual level is whether an individual currently works self-employed which can be interpreted as a latent variable being a function of the indpendent variables x_i. The latent variable is per definition not observable. Observable is however whether an individual currently works self-employed which is the dependent variable *y* and for which the probit model estimated can be specified as follows:

$$P(y = 1|x) = P(y = 1|x_1, x_2, ..., x_k) = \Phi(\beta x) \qquad (1)$$

In this model, *ß* is a vector of estimated coefficients and it is assumed that for the outcome in the binary variable of being self-employed, the value of the latent variable exceeds a pre-defined threshold value.[5] The cumulative distribution function in the probit model is based on a standard normal distribution and hence defined as follows:

$$\Phi(z) = \Phi(\beta x) \qquad (2)$$

The model itself is estimated with maximum likelihood and the estimation of the model is implemented using the STATA software. In the model, the independent variables are whether,

[4] In the analysis, the reference category are medium-sized firms and the effect of being a small or large firm is reported relative to this.

[5] One can think of this in terms of the latent variable being a utility level: if the utility for an individual of being self-employed (as predicted by the independent variables in the probit model) exceeds a pre-defined threshold value, then what should be observable is that the individual is self-employed. Essentially this means, that the values taken by the independent variables cause such a high value, that even taking into account statistical fluctuations as captured by the error term of the probit model, for the individual the utility is positive. Next to the binary current self-employment variable, a self-evaluation of the questionnaire respondents to which degree they agree with the statement that they would be self-employed within the next five years was also included in the survey questionnaire. The two variables are correlated ($p=0.32$, $p<0.01$), which supports my dependent variable.

respectively, the respondent stayed abroad for a practical placement or for his studies, a dummy for whether respondents finished a vocational training programme prior to their studies, gender, age of the respondent, whether the respondents parents are self-employed, an index score for environmental concern, an index score for originality based on Kirton (1976), as well as index scores for attitudes towards entrepreneurship, perceptions of difference and support factors. Next to these, in a variation of the model, an interaction term of environmental concern and originality or propensity to innovate is introduced to analyse the specific case of very innovative sustainability-related entrepreneurial opportunities. The basis for the analysis of the firm-level data is a three-category generalised ordered logit model which distinguishes between firms being ecopreneurs, bioneers, environmental managers, with the former corresponding to the highest and the latter being the lowest category. The generalised ordered logit model automatically tests whether the parallel lines assumption holds, or if coefficients differ significantly for different levels of the dependent variable. In case of the latter, the model is adjusted and differing coefficients are estimated for the relevant explanatory variables in order to ensure, that proportional odds can be assumed. Proceeding this way provides for more reliable results than using the standard ordered probit model, since in the latter, it may be that the parallel lines/proportional odds assumption is violated. The explanatory variables in the model are the (country-specific) values of the Environmental Sustainability Index (Esty & Porter 2001), four dummy variables for the level of industry environmental impact, size dummies for large and small firms, the age of the firm and whether the firm has a certified environmental management system.

Empirical Results

Results at the individual level

The result of the model estimation for the data at the individual level are summarised in Table 1 2.[6] As the R^2 values show, the models for both, students as well as alumni are all overall significant, as is clarified by the respective χ^2 statistics.

Looking first at the model without interaction effect for the student responses, Table 1 shows that female students are less likely entrepreneurs and older students are less likely to be self-employed. Students who studied abroad are more likely to pursue an entrepreneurial activity. Students who pursued a certified vocational qualification programme prior to their studies more likely to be self-employed. As concerns environmental concern, higher index scores makes these more likely to be self-employed, as does a generally more positive attitude towards entrepreneurship.

For the model including an interaction effect of environmental concern and innovativeness, environmental concern on its own becomes insignificant. Instead, the interaction term is significant and positive indicating that only for very high propensities to innovate environmental concern makes it more likely for a student to be an entrepreneur.

Turning to the alumni sample, Table 1 reveals that for the model without interaction term, female alumni behave with higher likelihood entrepreneurially. Opposed to this, alumni who pursued a vocational qualification prior to their studies are less likely to be self-employed. Alumni who studied abroad are less likely to pursue an entrepreneurial activity, whereas alumni who did a placement abroad are more likely to be self-employed. Alumni with a positive attitude to entrepreneurship are more likely to be entrepreneurs. Environmental concern is insignificant in the model without an interaction effect for the alumni sample. However, when introducing an interaction effect alumni with a high propensity to innovate, as

[6] In a variant of our model, we also included an interaction term of sustainability concern and propensity to innvate (i.e. Kirton's index score for originality) is introduced to analyse the effect of very innovative sustainability-related entrepreneurial opportunities. We do not find however significant evidence that the stronger the innovativeness, the stronger the impact of sustainability concerns on entrepreneurial intention. We therefore conclude that inclusion of an interaction term does not give insights beyond those reported in Table 2.

measured by the KAI index originality component and high environmental concern are more likely to pursue entrepreneurial activities.

Insert Table 1 here

Given that the models used in the analysis are non-linear, care has to be taken with regard to analyzing any interaction effects. As can be seen however, the marginal effect of the interaction term calculated based on the approach by Ai and Norton (2003) to correct for distortions in common software packages (such as STATA) for non-linear models is generally positive, but of differing magnitude for different observations.

Insert Figure 1 here

The concave curve in both figures provides the calculated interaction effect that would be (inccorectly) derived when using the method commonly applied to linear models.

Insert Figure 2 here

Results at the firm level

Table 2 summarise the results ofr the ordinal dependent variable at the firm level.[7] The insignificant Wald test of the parallel lines assumption indicates that the model reported does not violate the proportional odds/parallel-lines assumption.

The results provide support for H2a and H2b. As concerns H2a, smaller firms are, relative to mid-sized firms less likely to be an ecopreneur or a bioneer. Estimation of a multinomial model additionally reveals, that small firms are more likely to be environmental managers,

[7] For reasons of clarity and brevity marginal effects are not reported in the tables but are available from the authors upon request. All models are estimated with robust standard errors.

rather than bioneers and less likely to be ecopreneurs than bioneers, whereas large firms are more likely to be environmental managers, but not less likely to ecopreneurs. With regard to H2b, the significant positive coefficient indicates, that firms with an environmental management system are more likely to be a bioneer or ecopreneur.

Concerning H3a which proposed that the environmental impact of an industry is negatively associated with the likelihood of being classified as an ecopreneur, it is found that this only holds for very high levels of industry impact. These significantly reduce the likelihood of a firm to be classified as a bioneer or an ecopreneur.

Finally, as proposed in H3b the likelihood of being classified as an ecopreneur (relative to being a bioneer) is not significantly negatively associated with the age of a firm, yet the chance of a firm being a bioneer is negatively associated with age.

Insert Table 2 here

The results of the analysis remain qualitatively stable under a number of modifications of the initial model specification. These include using a continous variable for firm size (based on the number of employees of the firm) and incorporating the logarithm of firm age rather than firm age directly into the model. Furthermore, the results of the model do not change qualitatively, if instead of the Environmental Sustainability Index itself, dummy variables for high and low index values are used (based on the median index value) and if instead of the index a sub-category referring to social and institutional capacity only or dummy variables corresponding to those for the index were used. Furthermore, results did not change if instead of the dummy variables for industry environmental impacts the original 5-point rating scale was used based on the assumption of equidistant differences between levels.

Conclusions and Discussion

This chapter addresses empirical aspects of eco-entrepreneurship at both, the individual and firm levels. In doing so, it contributes to what can in many ways be identified as an important gap in eco-entrepreneurship research, namely analyses of empirical data based on large-scale surveys. This reasearch draws on two empirical surveys. Firstly, this is a survey of students and alumni of a large technical university. Secondly, the research combines secondary data on firms assigned to different categories of eco-entrepreneurship with primary data in a novel way that allows to provide more detailed insights as to the determinants of firm categorization. Six hypotheses are derived based on theory and extant literature with regard to these two data sets and are subsequently tested in the empirical analysis.

As concerns the hypotheses at the individual level, students with higher environmental concern are more likely to become self-employed which partly confirms H1a. Also for both, the student as well as the alumni sample, the interaction of innovativeness and environmental concern is significant and positive, thus fully confirming hypothesis H1b. Therefore, from the data emerges strong evidence of a moderating role of innovativeness on the link between environmental orientation of students and alumni and their entrepreneurial activity.

The insignificant effect of environmental concern in the alumni sample could be interpreted as a reality check that results from gaining business experience. This often discourages alumni with high environmental concern from pursuing entrepreneurial activities. As the model with the interaction effect shows, survival of this reality check only occurs for those alumni that have a high propensity to innovate. This is quite as expected in that only the „revealed preference“ of somebody having founded an eco-etrepreneurship venture is likely produce a positive interaction effect. Compared to this, for an alumni who has founded a venture but without having focussed necessarily on a highly innovative (e.g. radical innovation) opportunity the reality check weights stronger. Only ex-post therefore, the positive effect of being at the same time environmentally concerned with high innovation potential on founding

likelihood can be identified, as is done in our analysis using actual entrepreneurial activity as the dependent variable.

Looking at the models in Table 1 and specifically the result of the binary probit models for the group of alumni that females are more likely to be self-employed, it seems that this is at least partly due to limited employment options with heightened flexibility, as is possibly needed for women in families with children. However, it needs to be noted that this effect disappears in the model including an interaction term between propensity to innovate and environmental concern.

Concerning the hypotheses at the firm level, the analysis finds strong support for hypothesis H2b, partial support for H2a and H3a and no support for hypothesis H3b. The results concerning firm size imply that frequently debated issues concerning small firms being environmental laggards find some support (Tilley 1999; 2000; Hillary 2000). If firm size reflects firm visibility, given that larger firms tend to be more susceptible to public scrutiny, they are more likely to be industry leaders with regard to environmental management (Henriques & Sadorsky 1996). Opposed to this, SME are often found to be lessaware of their legal duties regarding waste disposal and frequently consider their operations not to have a significant environmental impact. In addition to that they tend to be less familiar with environmental management systems and standards and have bee found to respond strongest to regulation as a stimulus for environmental improvement (Petts *et al* 1999; Lefevre *et al* 2003; Lepoutre & Heene 2006). Brio and Junquera (2003) point out the difficulties of SME with regard to environmentally related cooperation activities. Opposed to this, Noci and Verganti (1999) argue that SME can be environmentally more proactive under specific conditions with regard to innovation and find that in this situation research and development cooperation of SME can be significant. These partly conflicting perspectives are also reflected in my findings, but at the same time reveal, that firm size per se is not a good predictor of small firms being an environmental manager or bioneer.

In this respect, the fact that small firms are more likely to be environmental managers, rather than bioneers and less likely to be ecopreneurs than bioneers, whereas large firms are more likely to be environmental managers, but not less likely to ecopreneurs indicates, that because of the high market impact required from ecopreneurs, firms in this category have to have a certain size, and hence large firms can well be ecopreneurs, but this depends on the level of priority that environmental management has in the firm, as is also signified by the environmental management system dummy.

Results concerning the latter show that environmental management systems can be understood as an enabler (helping to develop environmental management capabilitites), but most likely in the sense of a hygiene factor (Herzberg *et al* 1999), since many firms that have an EMS do not embody the characteristics of e.g. ecopreneurs.

Industry membership seems to predetermine to some degree the achievable level of environmental orientation in that the level of ecopreneur (high market influence and high priority of environmental objectives) and bioneer (high priority of objectives, but low market influence) may be not easily achievable by a firm from a highly-polluting industry.

The analysis also shows that the older a firm, the less likely it is to become a bioneer (relative to being an environmental manager). This provides an interesting perspective on eco-entrepreneurship as a reaction to increasing environmental concerns in society. Since firms in the category of environmental managers can be having both, large and low market impact, they are likely also relatively widely distributed across size classes. The results indicate, that of the small firms in this category, only the young ones have a high likelihood of transitioning to the bioneer status. Table 3 summarises the results of testing the hypotheses introduced earlier.

Insert Table 3

Overall, the results of this paper contribute to the literature on eco-entrepreneurship by providing an empirical grounding of eco-entrepreneurship at the individual and the firm level based on large-scale studies. In doing so, I fill an important gap in the literature on eco-entrepreneurship and enables a differentiated view on the potential of eco-entrepreneurship which is well-grounded in empirical analysis.

Limitations and future research

As concerns the scope of the research some limitations need to be acknowledged. First of all this is small sample size for the firm level data analysed. Whilst this almost certainly limits the representativeness of the data at hand, it still allows for an statistical analysis of the factors influencing classification of firms according to one commonly used classification scheme which so far has been missing. Furthermore, the data analysed is the largest possible data set currently available to empirically analyse the typology developed by Schaltegger and Petersen (2001). Finally, given that this terminology is very similar to a number of other typologies proposed (e.g. Risker 1998; Walley & Taylor 2002) the statistical analysis gives important insights into what factors may matter for these other typologies.

As concerns the individual level data analysed, it needs to be acknowledged as a limitation that only students and alumni at one university were surveyed. However, student samples are common in entrepreneurship research (see e.g. Lüthje & Franke 2003) and are also considered to be good approximations of samples of real-life entrepreneurs (Shane 2003). Furthermore, whilst sampling at only one university may again limit representativeness, it is rarely possible to comparatively analyse students and alumni. Therefore, it was considered acceptable to forsake some representativeness in order to gain this rather unique comparative perspective. In addition to this, the technical university at which the survey was conducted is one of the three largest ones in the country which ensures that purely because of its size, the results are likely still quite generalisable (see Lee & Baskerville 2003).

The findings I report in this chapter have some implications for both, entrepreneurship and educational policy as well as for corporate entrepreneurship (Dess *et al* 2003; Antoncic & Hisrich 2001). As concerns the former, the findings can inform the design of entrepreneurship education programs. Extant research indicates that specialized entrepreneurship programs are beneficial for the propensity to become self-employed (Charney & Libecap 2003; Matlay 2008). The results reported here suggest, that eco-entrepreneurship depends in this respect on a good blending of general entrepreneurship education and curriculum elements more targeted to entrepreneurial opportunities derived from environmental externalities or market failure (Cohen & Winn 2007; Dean & McMullen 2007). As concerns the latter for example large firms who want to be environmental managers or ecopreneurs probably need to ensure that their staff are not only trained on innovative orientation, but also on sustainability aspects, since the individual level analysis reveals, that only high propensity to innovate and high environmental orientation together drive eco-entrepreneur- and by analogy also intrapreneurship. As concerns policy makers, a need emerges from the link between propensity to innovate and environmental orientation to integrate environmental and innovation policy activities. This should be a focus of future research. Also, the effects of legal and financial systems on the exploitation of opportunities with high environmental benefits and the role of education, for example in terms of integrating environmental aspects in MBA business school curricula or using them as a means of entrepreneurial learning (Binks *et al* 2006; Harrison & Leitch 2005) should be analysed in future research. Future research should finally replicate my findings with larger firm-level samples and samples of alumni and students from other universities in order to corroborate the results reported here.

Acknowledgements

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Appendix

Insert Table A1 here

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Table 1: Results of binary probit model estimation without and with interaction effects

	Models without interaction		**Models with interaction effect**	
Variables	**Students**	**Alumni**	**Students**	**Alumni**
Environmental concern	0.504 †	0.199	-0.773	-1.888 **
	(0.283)	(0.104)	(0.497)	(0.687)
Propensity to innovate	-0.174	-0.110	-1.191 †	-2.739 **
	(0.261)	(0.294)	(0.706)	(0.894)
Interaction Environmental concern x Propensity to innovate	-	-	0.319 †	0.728 **
			(0.182)	(0.230)
Gender (2=female; 1=male)	-1.430 **	1.187 *	-0.866 *	0.750
	(0.532)	(0.593)	(0.306)	(0.480)
Age	-0.149 **	-0.004	-0.016	0.054
	(0.066)	(0.290)	(0.072)	(0.036)
Formal vocational training (2=no; 1=yes)	1.010 *	-1.065 *	1.099 **	-0.113
	(0.522)	(0.428)	(0.327)	(0.530)
Attitudes towards entrepreneurship	0.484 **	1.043 ***	0.455 **	1.182 ***
	(0.169)	(0.282)	(0.134)	(0.301)
Perceived barriers to entrepreneurship	-0.190	-0.372	-0.187	0.058
	(0.230)	(0.317)	(0.212)	(0.332)
Perceived support for entrepreneurship	-0.174	-0.256	-0.095	-0.272
	(0.226)	(0.325)	(0.219)	(0.302)
Studies abroad (1=yes; 0=no)	1.197 **	-0.027**	0.389	-0.650
	(0.405)	(0.013)	(0.427)	(0.442)
Parents self-employed (1=yes; 0=no)	0.369	-0.337	-0.005	0.414
	(0.3167)	(0.367)	(0.262)	(0.349)
Placement abroad (1=yes; 0=no)	0.150	0.679 †	0.451	0.508
	(0.465)	(0.405)	(0.413)	(0.373)
No. of observations (individuals)	313	125	313	125
Wald Chi²	57.56	41.56	280.30	52.68
p-value	<0.001	<0.05	<0.001	<0.001
Log likelihood	-43.75	-23.52	-58.64	-33.95

Significance levels: † $0.1 > p \geq 0.05$; * $0.05 > p \geq 0.01$; ** $0.01 > p \geq 0.001$; *** $p < 0.001$

Notes: Heteroskedasticity-robust standard errors in parentheses; marginal effects are available on request

Figure 1: Plot of interaction effects by observations for student sample

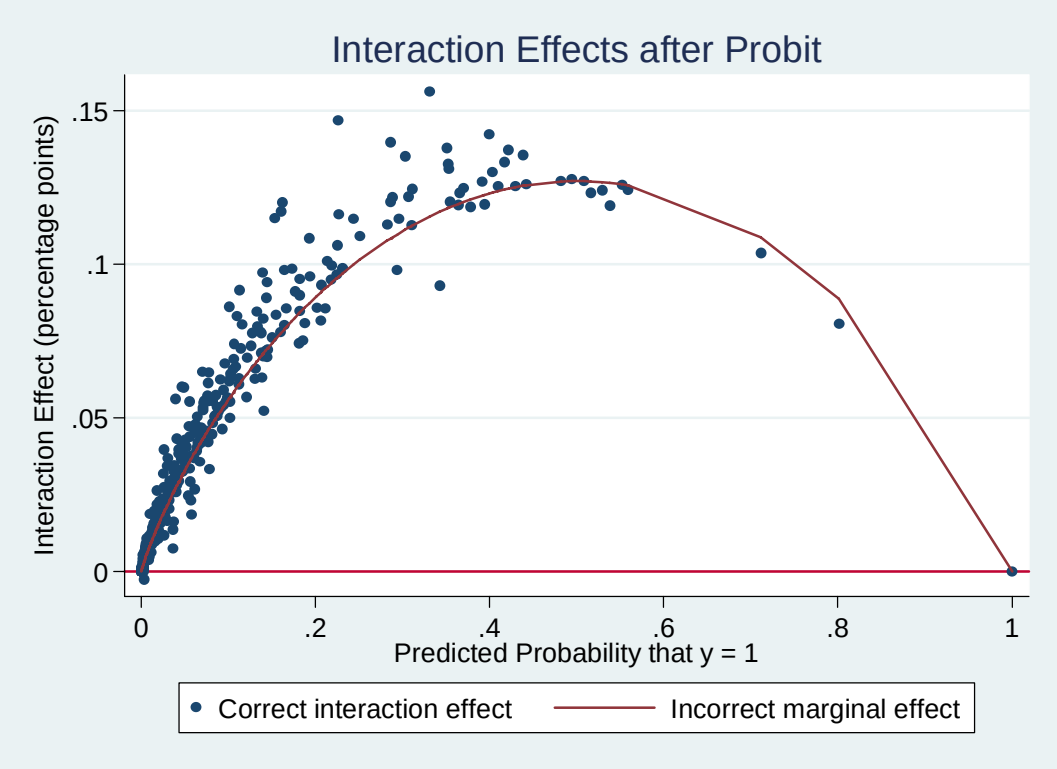

Figure 2: Plot of interaction effects by observations for alumni sample

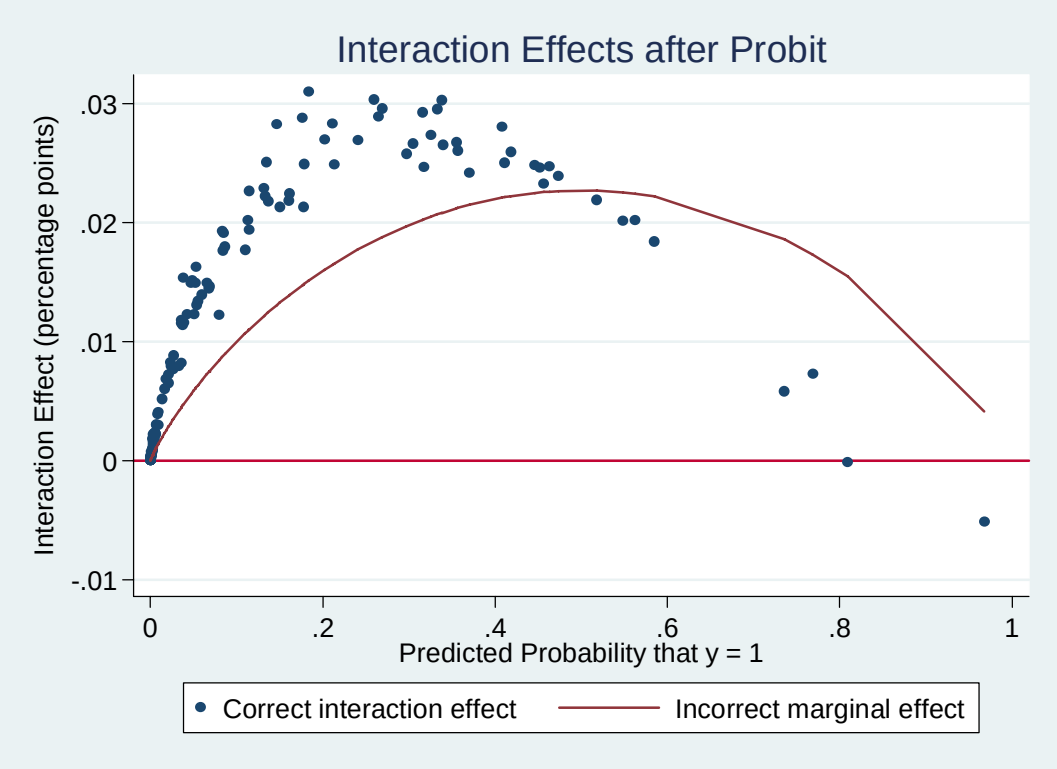

Table 2: Generalised ordered logit model for determinants of firm-level eco-entrepreneurship

Transition is from:	**Environmental Manager to Bioneer**	**Bioneer to Ecopreneur**
Industry impact (relative to no impact)		
Below-average impact	-0.395 (5.375)	
Average impact	-1.960 (2.055)	1.596 (1.740)
Above-average impact	-0.175 (1.629)	
Very high impact	-3.724 (2.118) †	
Firm age	-0.064 (0.022) **	-0.011 (0.016)
Firm size (relative to mid-sized firms)		
Small firm	-5.143 (2.102) *	
Large firm	-2.664 (1.661)	
Environmental management system	4.402 (1.458) **	
Country environmental sustainability level	-0.003 (0.057)	
Constant	8.260 (3.993) *	-0.346 (3.539)
No. of observations	41	
Wald test of parallel lines assumption	4.01	
Wald Chi²	31.90	
p-value	<0.001	
Log likelihood	-24.80	

Significance levels: † 0.1 > p ≥ 0.05; * 0.05 > p ≥ 0.01; ** 0.01 > p ≥ 0.001; *** p < 0.001
Notes: Heteroskedasticity-robust standard errors in parentheses; marginal effects are available on request

Table 3: Overview of the results of hypothesis testing

Hypothesis	Test result
1a	(+) *
1b	+
2a	(+)
2b	+
3a	(+)
3b	-

Notes: +: confirmed; (+): partly confirmed; -: disconfirmed; *: students only

Table A1: Descriptive statistics and correlations for students only

Variables		Mean	Std. Dev.	Min.	Max.	1	2	3	4	5	6	7	8	9	10	11
1	Gender	1.294		1	2											
2	Age	21.47	2.300	17	42	-0.105										
3	Studies abroad	0.073		0	1	0.006	0.220									
4	Placement abroad	0.070		0	1	-0.068	0.173	0.306								
5	Vocational training	1.889		1	2	-0.016	-0.462	-0.017	-0.021							
6	Parents self-employed	0.316		0	1	0.014	0.011	0.072	0.082	-0.086						
7	Sustainability orientation	3.949	0.649	2	5	-0.013	0.156	-0.024	0.024	-0.099	-0.104					
8	Propensity to innovate	2.600	0.537	1.2	4	0.057	0.034	-0.003	0.034	-0.053	-0.021	0.096				
9	Attitudes to entrepreneurship	2.701	0.811	1	5	-0.149	0.019	-0.012	0.122	0.032	0.050	0.002	0.130	0.130		
10	Perceived support	3.155	0.579	1	4.5	-0.044	-0.029	-0.008	-0.074	0.107	-0.014	0.091	0.108	0.126	0.136	
11	Perceived barriers	3.389	0.637	1	5	-0.021	0.043	0.011	-0.090	-0.012	-0.038	0.078	-0.092	-0.167	-0.023	-0.054

Notes: N=313; Correlations with an absolute value greater than 0.05 are significant at $p<0.05$

Table A2: Descriptive statistics and correlations for alumni only

Variables		Mean	Std. Dev.	Min.	Max.	1	2	3	4	5	6	7	8	9	10	11
1	Gender	1.179		1	2											
2	Age	34.121	5.254	25	48	-0.249										
3	Studies abroad	0.194		0	1	0.051	-0.214									
4	Placement abroad	0.298		0	1	0.082	-0.069	0.082								
5	Vocational training	1.880		1	2	0.102	-0.289	-0.006	0.242							
6	Parents self-employed	0.290		0	1	0.043	-0.188	-0.044	-0.029	0.019						
7	Sustainability orientation	4.024	0.718	1	5	0.225	0.049	0.083	-0.084	-0.143	-0.034					
8	Propensity to innovate	2.648	0.533	1	4	0.007	0.056	0.071	-0.066	0.062	-0.045	-0.46				
9	Attitudes to entrepreneurship	2.862	0.840	1	4.7	-0.204	0.164	0.049	-0.004	-0.002	0.134	-0.048	0.091	0.094		
10	Perceived support	2.887	0.547	1.5	4.5	-0.078	0.098	0.077	0.108	0.059	0.154	0.048	0.013	0.097	0.164	
11	Perceived barriers	3.426	0.633	1	5	-0.095	0.021	-0.148	0.007	0.087	0.131	0.123	-0.131	-0.056	0.102	0.091

Notes: N=125; Correlations with an absolute value greater than 0.05 are significant at $p<0.05$

Table A3: Descriptive statistics and correlations for firm-level analysis

Variables		Mean	Std. Dev.	Min.	Max.	1	2	3	4	5	6	7	8	9
1	Below average industry impact	0.024		0	1									
2	Average environ. industry impact	0.439		0	1	-0.140								
3	Above-average industry impact	0.293		0	1	-0.102	-0.569 ***							
4	High environmental industry impact	0.171		0	1	-0.072	-0.401 **	-0.292 †						
5	Age	45.951	37.003	4	140	-0.121	0.074	0.046	0.066					
6	Small-sized firms	0.268		0	1	-0.096	0.241	-0.148	-0.129	-0.370 *				
7	Large-sized firms	0.561		0	1	0.140	-0.010	0.137	-0.121	0.577 ***	-0.684 ***			
8	Environmental management system certified	0.585		0	1	-0.188	0.146	-0.112	0.119	0.355 *	-0.049	0.353 *		
9	Country environmental sustainability index	60.792	7.542	50.200	78.140	0.246	0.187	-0.178	-0.007	0.115	0.094	0.02	0.323 *	-0.133

Notes: N=41; Significance levels of correlations: † $0.1 > p \geq 0.05$; * $0.05 > p \geq 0.01$; ** $0.01 > p \geq 0.001$; *** $p < 0.001$