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Behavioural determinants of eco-innovation. A conceptual and empirical study

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Abstract
This study aims to contribute to the literature on the microeconomics of eco-innovation from a behavioural perspective. To this end, the Carnegie School´s model of the ´initiation of inno-vation´ was condensed into the empirically applicable model of the ?Composed Eco-Initiation Structure? (CEIS). The CEIS focuses upon the following three variables: general environmental goals, regulation-specific environmental goals and regulation-specific intentions to generate eco-innovations. As an empirical application, the willingness of German passenger car suppliers to undertake environmental product innovation as specified in article 4(1) of the European Union?s `End-of-life Vehicles Directive´ was investigated by a quantitative survey. Survey responses were evaluated using structural equation modelling with a special emphasis on effect sizes, which allows the evaluation of complex interrelations.
The results give ample evidence that internal behavioural aspects and external factors should be to be taken into account when analysing eco-innovation and designing environmental policies. The results indicate that environmental goals play a prominent role in eco-innovation. In addition, it appears that a mental accounting effect undergirds the relationship between innovations in general and eco-innovations in particular that should be investigated further and most likely requires specially designed policy instruments.

Jelcodes:Q55,L5

Behavioural determinants of eco-innovation

A conceptual and empirical study

1. Introduction

An analysis of the determinants of companies' eco-innovative behaviour is important in empirically oriented ecological economics because of the strain that has been put on natural resources by global economic activity. When addressing these matters in research, reference is made generally to the approaches utilised in innovation economics, which is supplemented by the genuine specifics of eco-innovation (Demirel and Kesidou, 2011; Kemp and Pearson, 2007 OECD, 2010 and Rennings, 2000). However, the application of approaches and indicators from innovation economics leads to several problems that, along with the diversity of the objects of study (Bernauer et al., 2006 and Kammerer, 2009), may explain why the findings of empirical eco-innovation research are relatively heterogeneous and in some cases even contradictory (see ibid.). Empirical innovation research does have a well-defined set of indicators at its disposal but that some of these are known to have inherent problems that limit their suitability; this is the case, for example, with R&D and patent indicators (Griliches 1990; Grupp 1998, 190ff. and Kleinknecht et al. 2002, 110f.). Moreover there is one significant area of knowledge that is not systematically considered, which is the agent-based analysis of the behavioural determinants of companies' decisions to undertake innovations.

The adoption of this limited perspective is problematic for eco-innovation research. On the one hand, it generally confines the potential to evaluate eco-innovative activity as specific behaviour of market players, and, therefore, it limits the potential to gain a better understanding of the conditions in which companies decide to undertake eco-innovation. On the other hand, it specifically limits the analysis of the (prospective) effects of regulations on eco-innovative behaviour. This raises the question of how to outline a behavioural analysis of this type and what theoretical approaches to use in undertaking this task.

This is the starting point for the present study. The aim is to make a theoretically and empirically grounded contribution to eco-innovation research that is based on a behavioural perspective, and the question to be investigated is what determinants make German passenger car suppliers decide to undertake environmental product innovations. This study focuses on a specific type of eco-innovation, the sustainable product design of automobiles set out in article 4(1) of the European Union's 'End-of-life Vehicles Directive' (ELVD) (or in the national implementation of this directive in Germany). The behavioural foundation is realised by referring to the Carnegie School's 'theory of the firm'; this theory is fundamental for evolutionary-oriented innovation economics in addition to organisational research. However, it is little known that the approach of the Carnegie School comprises a model called ´initiation of innovation´ that explicitly incorporates a behavioural perspective with respect to the factors influencing the decision to innovate.

Section 2 briefly summarises and explains the Carnegie School's initiation model. Section 3 provides an overview of the sector and the specifics of the regulation in focus. In section 4, the initiation model is reformulated as the 'Composed Eco-Initiation Structure' (CEIS), and the hypotheses to be tested are developed. Sections 5 and 6 concentrate on the empirical analysis and on presenting the dataset, method and results. Section 7 closes this article with a summary and outlines recommendations for further research and for the design of environmental policy instruments.

2. The Carnegie School's model of the 'initiation of innovation'[1]

The aspects of behaviour examined by the Carnegie School cover a broad range of relevant topics; one prominent focus, however, lies in the tension between "action and inaction" or "persistence and change" (March and Simon, 1993/1958, 195) that is found between routine and innovation. The assumption here is that firms act strategically and interact with their corporate environment, which forces them to adapt to new circumstances by overcoming routines – by learning, innovating, and changing the form and substance of their goals – to survive in the market (Levinthal and March, 1981; March and Simon, 1993/1958 and Simon, 1993, 1991).

In this context, the Carnegie School drew a fundamental but little-noticed distinction early on between the decision to undertake and encourage innovation,[2] on the one hand, and the

[1] Herbert Simon's early work, 'Administrative Behavior' (1997/1947), and the publications resulting from his collaboration with Richard Cyert and James March at the 'Carnegie Institute of Technology', in particular, the works entitled 'The Behavioral Theory of the Firm' (Cyert and March, 1992/1963) and 'Organizations' (March and Simon, 1993/1958), are today considered as foundation the Carnegie-School (Gavetti et al., 2007).

[2] The definition of innovation used by the Carnegie School is consistent with the definition given in the Oslo Manual (see, e.g., March, 1994).

ensuing implementation of the process of innovation, on the other. In particular, March and Simon were concerned with the former, presenting this for the first time as the model of the 'initiation of innovation'[3] in 'Organizations' (1993/1958). The following outline of the three core components of the initiation model is to be understood as a desideratum of the thematic features in 'Organizations' and the subsequent works of the Carnegie School.

The first core component of the initiation model is the goal-orientation of corporate behaviour, and, therefore, of current corporate goals (see for this and subsequent remarks in this section as far as not mentioned otherwise Cyert and March, 1992/1963; March and Simon, 1993/1958; Simon, 1997/1947, 1996, 1993). The Carnegie School differentiates between aggregated and constitutive overall goals, such as turnover, profit, sales, company size, market share and satisfaction of customer needs, on the one hand, and operative goals that serve to implement these, on the other hand (Simon, 1991, 1964, 1963). It is assumed that goals adapt to internal and external changes in conditions through learning processes and that new goals can arise in this process (Levinthal and March, 1981 and Simon, 1997/1947).

Within the framework of the concept of satisficing, it is assumed that companies form aspirations to reach each goal within a given time period and then compare this with the goal actually reached or anticipated (Simon, 1991, 1964, 1963). If the discrepancy between the desired and attained/anticipated target height is too great – and if lowering the target height to the level attainable is not satisficing – a search for possible innovations is conducted with the expectation that the desired target and aspiration will be reached when these innovations are achieved (for more detail see Beckenbach et al. 2012).

The second core component of the initiation model is integration of the corporate environment into the decision-making context. The Carnegie School assumes that continuous engagement with the environment is necessary to identify problem areas that might jeopardise existing goals and/or require the development of new goals. The problem areas mentioned here are current or anticipated demands of, or changes in, the environment. The environment includes shareholders, customers, service providers, suppliers and state institutions. Examples of environmental demands include customer wishes, regulatory enforcement and

[3] Other authors using this term can be found in management and organisational research (Damanpour, 1996; Daft, 1978; Glynn, 1996 and Rice et al., 2001), although most of these reference Rogers (1995) instead of the Carnegie School.

social pressure. Environmental changes are manifested, for example, in the competitive structure, technological progress, and uncontrollable “external shocks” (Cyert and March, 1992/1963, 118).

The third core component of the initiation model encompasses the characteristics of agents relevant to decision-making and corporate conduct in the context of bounded or procedural rationality. Thus, for instance, the perception of problems is dependent on the ability to recognise relevant future trends and developments (March, 1991 and Simon, 1999, 1985). The willingness to engage with processes of change to address perceived problems and to initiate the search for new solutions (innovations) in this respect thus depends on the general attitude towards innovation. Furthermore, individual traits and behavioural characteristics, such as risk taking, experimentation, playfulness, creativity, flexibility and discovery are also of relevance for the decision to innovate and for the ability to conduct innovations (March, 1991, 1994 and Simon, 1985, 1999). Additionally, the degree of specific expert knowledge built up over time, corresponding experiences in the past (Prietula and Simon, 1989 and Simon, 1999, 1993) and the nature and extent of the monetary resources available (e.g., in terms of slack) are important in this context.

The interplay of these three components characterises the nucleus of the initiation model, and the initiation of innovation is thought to be a process that begins with the perception of a problem that seems to endanger currently existing goals. Furthermore, the process comprises the analysis of the perceived problem, the search for problem-solving strategies, and, if no strategy for solving the problem can be identified within the existing repertoire of actions, the search for alternative strategies, i.e., innovation. The end of the initiation process is then the (strategic) decision for or against undertaking innovation. The decision to innovate is embedded, therefore, in a network of effects determined by agent-specific goals, by endowment with relevant skills or resources and by environmental influences. Depending on the particular situational problem and on agent specificities, heterogeneous decision-making patterns may emerge.

3. Sector and regulation

The automotive industry is one of the most important sectors worldwide, in the European Union and in Germany; in the European Union, more than 12 million people are employed in this industry (European Commission, 2012). Producing passenger cars is an important part of this industry; in 2010 alone, approximately 15 million passenger cars were manufactured in the European Union, with 5.5 million of these coming from Germany (ACEA, 2011). However, it is widely understood that the sector was hit hard by the recent financial crisis, which reinforced consolidation processes from increasing competitive pressures that have long been discernible in the automotive industry. These pressures manifest first in consolidation and concentration among original equipment manufacturers (OEMs) and suppliers and in a decreasing vertical integration, which is linked to the shift of production and R&D processes to suppliers (Chanaron and Rennard, 2007; Mondragon et al., 2006; Parry and Roehrich, 2009 and Proff, 2011). Thus, automotive suppliers play an increasingly important role in the automotive industry.

The counterpart to the production of automobiles is the disposal of vehicles after usage. The European Commission assumes that Europe incurs approximately eight to nine million tons of waste in the form of old vehicles every year;[4] in Germany alone, the figure in 2010 was 516,128 tons, according to Eurostat.[5] The corresponding waste management process is regulated in the European Union by the 'End-of-Life Vehicles Directive' (ELVD) (Directive 2000/53/EC)[6] and by regulations implementing the ELVD in member states. According to the ELVD, the goal is to recover and reuse of at least 95% of the average weight of an automobile; by 2015, at least 85% of the average weight of an automobile is to be reused and recycled in member states. In article 4(1), the ELVD also imposes the following language on member states:

> "In order to promote the prevention of waste, Member States shall encourage, in particular: (a) vehicle manufacturers, in liaison with material and equipment manufacturers, to limit the use of hazardous substances in vehicles and to reduce them as far as possible from the conception of the vehicle onwards, so as in particular to prevent their release into the environment, make recycling easier, and avoid the need to dispose of hazardous waste;
>
> (b) the design and production of new vehicles which will take into full account and facilitate the dismantling, reuse and recovery, in particular the recycling, of end-of-life vehicles, their components and materials;

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[4] http://ec.europa.eu/environment/waste/elv_index.htm; last accessed 22.10.2012.

[5] http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do; last accessed 22.10.2012.

[6] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32000L0053:EN:NOT; last accessed 22.10.2012.

(c) vehicle manufacturers, in liaison with material and equipment manufacturers, to integrate an increasing quantity of recycled material in vehicles and other products, in order to develop the markets for recycled materials."[7]

Article 4(1) of the ELVD thus explicitly links two areas that characterise the beginning and end of the motor vehicle life cycle, product development and recycling (Mazzanti and Zoboli, 2006). The ELVD does not, however, specify how article 4(1) is to be implemented. Clearly, this regulation appears to be more request than obligation; this is evident in the German implementation of the ELVD, the 'Altfahrzeugverordnung' ('End-of-life vehicles ordinance'),[8] which, like the ELVD, does not stipulate any measures for non-compliance.

In light of the above, and because of the increasing tendency to shift R&D processes to suppliers, the question is to what extent and why these suppliers to the passenger car industry take into account the elements of article 4(1) of the ELVD. The aim of the following sections is to examine whether adopting the Carnegie School's concept of initiation can contribute to explaining the answer to this question.

4. Specification of the 'Composed Eco-Initiation Structure' and hypotheses

4.1. The 'Composed Eco-Initiation Structure'

In order to reformulate the initiation model into an empirically accessible model, three premises were taken collectively as the basis for the starting point. First, eco-innovative activities were interpreted as specific sub-areas of companies' 'normal' innovation activities. Second, following Fishbein and Ajzen (2010/1975) and in accordance with the initiation model, it was assumed that an intention to act that results from the decision-making process represents the decision to undertake an action, and that analysing the determinants of such an intention allows more distortion-free results than analysing the determinants of a past action. With this in mind, the type of eco-innovation to be investigated represents the extent to which suppliers in the passenger car industry intend to pursue, and expend resources on, product developments relating to article 4(1) of the ELVD in the context of general product innovation activities over the next five years. By emphasising the intention to act, the object

[7] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32000L0053:EN:HTML; last accessed 29.10.2012.

[8] http://bundesrecht.juris.de/bundesrecht/altautov/gesamt.pdf; last accessed 22.10.2012.

of investigation in the present study differs from that found in most other empirical studies on eco-innovation because these studies typically focus on past eco-innovative activities instead of future actions (but see Corral, 2003).

As stated in section 2.2 above, with regard to the first component of the initiation model, the goals of a firm play the dominant role in the decision to innovate. However, focusing only on the economic goals typically referred to by the Carnegie School would be inadequate for this study. If goals are determinants of the general decision to innovate, then we must ask to what extent the decision to undertake environmental innovations in particular (as a specific type of innovation) is based on corresponding objectives, i.e., environmental goals, and why and to what extent firms develop environmental goals. Thus, environmental goals as objects of investigation come into focus, too. This perspective corresponds to the approach of the Carnegie School, which notes that new types of goals may be formed in the course of the adaption processes.

Third, with this in mind, it is assumed that there are environmental goals within a company's set of goals to be identified and that the levels of these goals determine the decision to conduct eco-innovations. Furthermore, two type of goals of innovation can be distinguished that correspond to the Carnegie School's distinction between constitutive goals and operative goals; on the one hand, there are general environment-related goals, and, on the other hand, there are operative goals that are related to the specificities of the subsequent field. In the context of this study, the latter should be evident in the adoption of the subject matter of article 4(1) ELVD. This accords with Porter and van der Linde (1995), who assume that sufficiently stringent regulations may lead to a specification of goals in relation to the contents of eco-innovations.

The interplay between the two types of environmental goals and the specific type of eco-innovation focused upon in this study is summarised in the following as the 'Composed Eco-Initiation Structure', which is depicted by Hypothesis 1 as follows:

H1. Environment-related goals have a positive effect on eco-innovative intentions (H1a). General environmental goals affect the intensity of regulation-specific environmental objectives (H1b). These objectives, in turn, have a stronger effect on eco-innovative intentions than general environmental goals (H1c).

In keeping with the structure and complexity of the initiation model and its emphasis on the relevance of goals for the decision to innovate, the following section (4.2) relates each of the subsequent hypotheses to all three variables of the CEIS and examines them in the statistical analyses accordingly (section 6).[9] In this respect, the present study has an exploratory character based on the expectation that the distinction between the two types of goals and the eco-innovative intention as endogenous variables offers a more detailed perspective on the factors determining eco-innovation than that achieved in other studies.

4.2. The determinants of the CEIS

In the following, the (possible) determinants of the CEIS are derived from the initiation model by adapting relevant aspects of the three core components, thereby referring to findings of empirical innovation research in general and of empirical eco-innovation research in particular. Altogether, the following four aspects are considered (see figure 1): (i) the attitude towards (eco-)innovation; (ii) the relevant resources (both of the first two aspects are comprised in the third component of the initiation model regarding the relevant characteristics of the agents); (iii) 'hard' economic goals (which is consistent with the first component of the initiation model and once more takes into account the significance of goals); and (iv) the effect of market conditions and of external shocks, which are both parts of the second component of the initiation model.

(i) With respect to the first aspect to be considered, the attitude toward (eco-)innovation, the following two assumptions are made with regard to the CEIS: first, that attitudes towards innovation in general and eco-innovation in particular determine the level of environmental goals and the level of eco-innovation and, second, that attitudes may be represented via a corresponding classification of types of agents, particularly in terms of whether their environmental-related behaviour tends to be pro-active, reactive, or independent of legislation. Hypothesis 2 (H2) summarises these aspects as the following:

H2. The attitude toward innovations in general (H2a) and the specific 'green' type of agent in particular (H2b) has a positive effect on the level of the endogenous variables of the CEIS.

The influence of attitudes on innovation in general has been confirmed by Candel and Pennings (1999) and Sawang and Unsworth (2011), among others, and on eco-innovation of

[9] Thus, both variables concerning goals are also endogenous as exogenous variables; this is possible because of the chosen statistical method (see section 5.2).

firms in particular by Corral (2003). The relevance of ´green´ types of agents has been addressed mainly in management-oriented environmental research but without reference to eco-innovation (Aragón-Correa and Rubio-López, 2007; Buysse and Verbeke, 2003; Kagan et al., 2003 and Murillo-Luna et al., 2008).

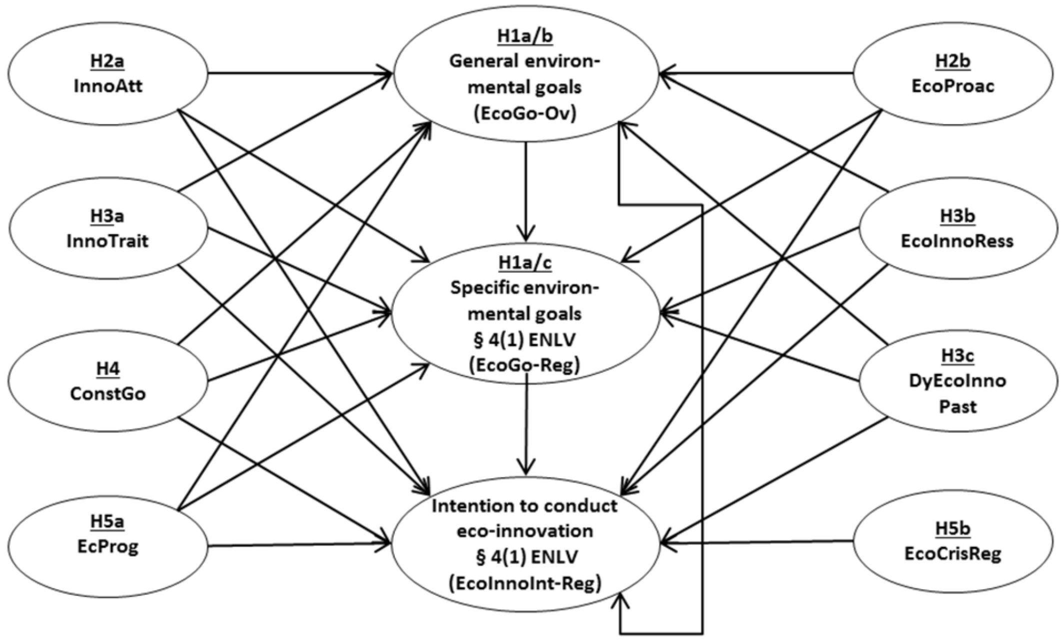

Figure 1: The CEIS model. The core structure is positioned in the centre. The latent variables on the right represent behavioural aspects related to environmental issues, and the latent variables on the left represent innovation aspects related to innovation in general (except `EcProg´; for variable names and items, see table 1).

(ii) With respect to the second aspect to be considered, the relevant resources, when these are taken into consideration as determinants of the CEIS, they include abilities related to innovation in general, such as risk taking, experimentation and creativity. The relevance of these specific traits has been confirmed by the insights of creativity research (Amabile, 1997; Ames and Runco, 2005 and Magee, 2002). Corresponding approaches are also found in ecopreneurship research (Hansen et al., 2012 and Isaak, 2005).

In eco-innovation research, the relevance of specific capabilities is discussed in the context of applying the resource-based view of the firm to environmental firm behaviour (Hart, 1995 and Kammerer, 2009). Furthermore, certain authors see the implementation of environmental management systems as the expression of ‘green capabilities’ and observe a positive influence on eco-innovation (Kammerer, 2009; Kesidou and Demirel, 2012; Khanna, et al. 2009 and Rennings et al., 2006). Additionally, past eco-innovative activities are considered important because those might imply that specific qualifications have been developed. A corresponding analysis may be found in Rehfeld et al. (2007), who observe a significant correlation between past and planned eco-innovations, which are distinguished according to different types of eco-innovation (see also Horbach (2008)). Frequently, however, reference is made to the classic R&D variables as an expression of competency, with a predominantly positive influence being observed (Antonioli and Mazzanti, 2009; Horbach, 2008; Arimura et al., 2007 and Scott, 2003).[10]. In the following, Hypothesis 3 (H3) summarises the above discussion:

<u>**H3.** The level of characteristics relevant for innovation in general (H3a), the particular resources available for environmental product innovations (H3b), and past eco-innovation behaviour (H3c) have a positive effect on the level of the endogenous variables of the CEIS.</u>

(iii) With respect to the third aspect, the role of constitutive ‘hard’ corporate goals as drivers of innovation, corresponding ideas may be found in the literature on innovation. In the context of the European Union’s Community Innovations Statistics[11], for example, a number of goals were revealed. For the survey period 2006 to 2008, expansion of the product range was the most commonly mentioned goal, and the goals of increasing market share and lowering costs were mentioned less frequently (Eurostat 2012, see also Wörter et al., 2010). However, the latter has been proven to be a relevant driver of eco-innovation in eco-innovation research, according to Horbach et al. (2012) (see also Belin et al., 2009; Cleff and Rennings, 1999; Frondel et al., 2008; Green et al., 1994 and Rennings and Rammer, 2009). This is taken into consideration in Hypothesis 4 (H4), which states the following:

<u>**H4.** ‘Hard’ economic goals have a positive effect on the level of the endogenous variables of the CEIS.</u>

(iv) With respect to the fourth aspect to be considered, the effect of market forces and external shocks, the relevance of market forces and competition has been debated in the literature on innovation at least since Schumpeter and is prominently advocated by Porter (1998, 1990); Boone (2000) and Vives (2008), among others, offer empirical evidence with respect to ‘normal innovations’. From a similar perspective, Horbach (2008) notes a positive correlation between eco-innovation and expected performance in the form of expected demand.

[10] With regard to the problems this indicator displays (see fn. 1), this topic is not included in this hypothesis (but see fn. 25 for related statistical findings).

11 Http://epp.eurostat.ec.europa.eu/portal/page/portal/microdata/cis; last accessed 20.11.2012.

Furthermore, the crisis in the automotive industry that prevailed at the time of the survey might be considered an 'external shock' by the Carnegie School. Thus far, there are not many studies about the effect of the crisis on innovation behaviour in general and none focusing on eco-innovative behaviour in particular. As for the former, Filippetti and Archibugi (2011) find evidence that European firms have not changed their innovation expenditure overall but are nonetheless starting fewer new projects. In Germany, according to Rammer (2011), the crisis has had heterogeneous effects on innovative activities that are related to the extent of companies' innovation activities before the crisis – companies with higher levels of innovation activity are more likely to regard innovations as a strategy for addressing the crisis. As applied to this study, this can be summarised in the following Hypothesis 5 (H5):

H 5. Anticipated market conditions in general have an effect on the level of the endogenous variables of the CEIS (H5a). In particular, the crisis in the automobile industry influenced eco-innovative intentions in terms of article 4(1) ELVD (H5b).[12]

5. Data and methodology

The present study is based on a quantitative survey of the German passenger vehicle supply industry from 2009 undertaken as part of the project "Ecological Perspectives of Modularisation", which was funded by the German Volkswagen Foundation.[13] Obtaining the address data was relatively labour-intensive because of unclear distinctions in the NACE-codes and the study's restricted focus on the passenger vehicle supply industry. Initially, five commercially available publications and databases accessible on the Internet were analysed, and 2400 suppliers were identified. Approximately 1700 of these were contacted by telephone, first to establish whether they belonged to the target group and, second, to find suitably qualified contacts (the relevant information was available for approximately 700 companies; see Automobilproduktion, 2007).[14] The final address dataset to which the questionnaire was sent to comprised 1319 suppliers; it can be assumed that the population was effectively covered.

The rate of return of usable answers was 21%, and 279 completed questionnaires were avail-

[12] Part 5b of hypothesis 5 is related only to eco-innovation because this was directly focused on in ELVD article 4(1) in the survey (see table 1) and, therefore, covers a specific decision made by the companies.

[13] Http://www.uni-kassel.de/beckenbach/index.php?option=com_content&view=article&id=14&Itemid=5 &lang=e; lastly accessed 8.11.2012.

[14] The contacts established were either managing directors, senior employees in R&D, or persons working in the environmental field.

able for statistical analysis. Of the responding firms, 56% could be classified as large-scale enterprises, 33% as medium-sized enterprises, and 10% as small and micro enterprises, according to the European Commission's system of classification by company size (2005). Of these companies, 66% stated that they belonged (at least) to the first tier in the value chain, 28% of companies were part of the 2nd tier, and only 6% of companies belonged to the 3rd tier. The median age of the businesses, 49 years old, was relatively high, which might be explained by the long tradition of automobile production in Germany.

The statistical analysis was undertaken using the method of structural equation modelling, more specifically the 'partial least square' approach (PLS-SEM) developed by Wold. The analysis also follows the guidelines of the American Psychological Association's 'Statistical Task Force' (Wilkinson and Task Force on Statistical Inference, 1999) and refers to effect sizes[15] f^2, whereby distinctions are drawn between the direct effects and resulting effect sizes[16], on the one hand, and the total effects[17] and resulting effect sizes, on the other.

6. Empirical results

6.1. Outer Model

With respect to the outer model, it is necessary to evaluate to what extent the indicators used are suitable for representing the latent variables. Table 1 shows an overview of the latent variables, the associated items and the relevant questions in the questionnaire; mean and standard deviations are also shown (see also Appendix A). Concerning the assessment of the outer model, the empirical test criteria all achieve satisfactory values (for these, see Hair et al., 2012); thus the outer model is confirmed (see Appendix B).

[15] Effect sizes measure the relevance of an effect without reference to the level of significance and, therefore, are independent of the sample size (Cohen, 1988 and Hair et al., 2009).

[16] Cohen (1992) differentiates the following three classes of effect size: 0.02 < 0.15 (low), 0.15 < 0.35 (medium) ≥0.35 (large) (this distinction should be seen as a rough guideline and is increasingly criticised (e.g. Ferguson, (2009)).

[17] Total effects are composed of the sum of the direct effect and the indirect effects, and, therefore, contain both the direct influence of an exogenous variable on an endogenous variable and the indirect influence which it exerts via the other variables related to it; the same applies to effect sizes (Cohen, 2003).

Table 1: Latent variables, their indicators and the corresponding questions in the questionnaire

Latent variable	Item	Question in the survey	x̄	sd
EcoInnoInt-Reg	EcoIntEx	To what extent will your company, in the next five years, take into account the aspects relating to article 4(1) ELVD in product development?	3.63	1.50
	EcoIntRs	To what extent will your company, in the next five years, expend resources for development relating to article 4(1) ELVD in product development?	2.66	1.30
EcoGo-Ov (H1a/b)	EcGoRg	Goal of product development: compliance with environmental legislation	4.81	1.31
	EcGoEcBa	Goal of product development: improving ecological balance	3.62	1.32
	EcGoEcFe	Goal of product development: improving ecological features	3.95	1.35
	EcGoEcCo	Goal of product development: improving environmental compatibility	4.64	1.28
EcoGo-Reg (H1a/c)	EcGoRegRM	Goal of product development §4(1): use of recycled materials	3.33	1.64
	EcGoRegED	Goal of product development §4(1): ease of disassembly	3.25	1.48
	EcGoRegPR	Goal of product development §4(1): potential for reuse	2.99	1.59
	EcGoRegRy	Goal of product development §4(1): recycling	3.54	1.53
InnoAtt (H2a)	InAtSM	Without product development, our company cannot survive on the market.	5.16	1.26
	InAtCC	Product developments are an important component of our corporate culture.	5.14	1.05
	InAtRi_Re	Product developments are generally linked with excessively high risks (recoded).	4.29	1.37
	InAtCG	Product developments are important for the attainment of our corporate goals.	5.48	0.83
	InAtRC	Product developments are important for the reputation of the company.	5.16	1.00
EcoProac (H2b)	EcPrBv	Our company usually adapts to the requirements of environmental laws and regulations before they come into force.	4.25	1.48
	EcPrWh	We always implement the environmental laws and regulations affecting our company promptly when they come into force.	5.02	1.10
	EcPrNc_Re	We generally fulfil environmental laws and regulations only to the extent absolutely necessary (recoded).	3.73	1.61
	EcPrId	Our company takes into account ecological aspects of product design and production independent of legislation.	4.33	1.29
InnoTrait (H3a)	ITWE	Characteristic of the company: willingness to experiment	4.45	1.16
	ITNO	Characteristic of the company: ability to seize new opportunities	4.74	1.01
	ITWR	Characteristic of the company: willingness to take risks	4.10	1.17
	ITCR	Characteristic of the company: creativity	4.31	1.13
	ITQI	We can quickly adopt and implement interesting ideas for product development	4.89	1.00
EcoInnoRess (H3b)	EcIRC	Excessively high costs make it difficult to take into account the aspects relating to article 4(1) ELVD in product development.	2.86	1.52
	EcIREK	A lack of expert knowledge makes it difficult to take into account the aspects relating to article 4(1) ELVD in product development.	2.46	1.40
	EcIIn	A lack of information about the topic makes it difficult to take into account the aspects relating to article 4(1) ELVD in product development.	3.04	1.58
DyEcoInno Past (H3c)	InnoVerg	Dummy: has your company, in the last five years, taken into account the aspects relating to article 4(1) ELVD in product development?	yes: 38%; no: 62%	
ConstGo (H4)	CGR	Goal of product development: improving returns	5.06	1.09
	CGC	Goal of product development: lowering production costs	5.20	1.05
	CG	Goal of product development: raising unit cost return	5.10	1.01
EcProg (H5a)	EcPT	Prognosis: turnover in the next five years	3.96	0.95
	ECPP	Prognosis: profit in the next five years	3.49	1.06
	ECPE	Prognosis: number of employees in the next five years	3.30	0.89
EcoCris-Reg (H5b)	ECR	In the context of the crisis in the automotive industry, our company will in future invest more in product improvement as stipulated in article 4(1) ELVD.	2.48	1.23

Notes: (a) In the questionnaire, the questions themselves did not mention article 4(1) of the ELVD but the identical German transposition in the 'Altfahrzeugverordnung', which is related explicitly to passenger cars. (b) The assumption underlying \`EcoGo-Ov´ was that the goal 'compliance with environmental legislation' (\`EcGoRg´) does not work as a singular goal but is embedded in a more general set of environment-related goals. In addition, however, its influence was tested separately as a single item variable. A significant and direct path to \`EcoGo-Ov´ emerged with a moderate effect size and also a further path to \`InnoInt-Reg´ without sufficient effect size (see Appendix C); this confirms the present assumption.

6.2. Inner model

At the centre of the present study is the inner model by which the hypotheses formulated in section 4 are tested (see figures 2 and 3 and Appendix C). Because there are three dependent variables within the CEIS, the inner model encompasses three regressions. The results show that the adjusted coefficients of determination ($\underline{R^2_{adj.}}$[18]) reach relatively high levels with values of 0.264 (`EcoGo-Ov´), 0.419 (`EcoGo-Reg´) and 0.577 (`EcoInnoInt-Reg´). Because the three values of the cross-validated redundancy measure $\underline{Q^2}$ of Stone (1974) and Geisser (1974)[19] are well above zero, the predictive relevance of the regression models is given. Furthermore, Hypothesis 1 can be confirmed because the variable `EcoGo-Ov´ exerts a strong influence on `EcoGo-Reg´; the latter also has a strong influence on `EcoInnoInt-Reg´ and, furthermore, `EcoGo-Ov´ has no direct effect on `EcoInnoInt-Reg´ but does have an indirect effect on `EcoInnoInt-Reg´ via `EcoGo-Reg´.

In the following presentation of the results with respect to hypotheses 2-3, a distinction is drawn between aspects of behaviour which are related to (i) eco-innovation in particular (H2b, H3b, H3c, H5b) and (ii) innovation in general (H2a, H3a, H4, H5a).

(i) With respect to eco-innovation in particular and with reference to the relevance of the influence of the 'green' type of agent, there is to be observed only one significant and direct, but strong, path from `Eco-Proac´ to `EcoGo-Ov´. However, the values of the total effects show that the type of agent has an indirect effect on `EcoGo-Reg´ and `EcoInnoInt-Reg´ via `EcoGo-Ov´ – therefore, H2b is confirmed.

Somewhat surprisingly, the findings on the relevance of the resources evaluated that are specifically related to the requirements of article 4(1) ELVD (H3b,c) show that EcoInnoress´ (H3b) has no significant effect at all.[20] However, the corresponding questions in the questionnaire covered deficits in endowment (see table 1); thus, it can be assumed that the extent of deficits in resource endowment has no relevance for the level of the three endoge-

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[18] The recommendation of Leach and Henson (2007) was followed and the adjusted $\underline{R^2}$ calculated using Lord´s formular 1.

[19] $\underline{Q^2}$ is based on a blindfolding procedure and "represents a measure of how well-observed values are reconstructed by the model and its parameters" (Chin, 1998, 318; see also Hair et al., 2012).

[20] We also tested whether the three types of resources influence the endogenous variables severally; this is not the case.

nous variables. It would be incorrect, however, to suggest the opposite conclusion that the presence of resources has a positive effect. H3b is therefore not confirmed.

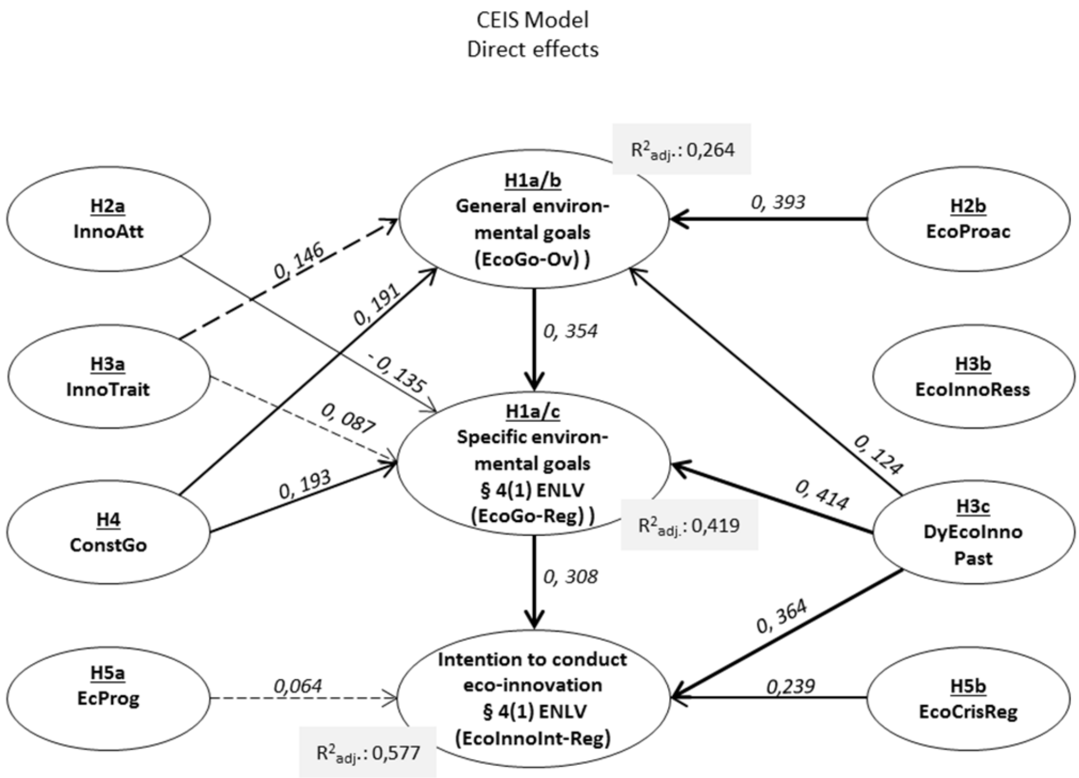

Figure 2: The CEIS model – direct effects. The latent variables of the model are shown (see tab. 1) but only the significant paths (see Appendix B; the dotted lines indicate a significance level of < 0.05 (two-tailed)). The thickness of the arrows reflects the effect sizes, corresponding to Cohen's classification – thin: no relevant effect; medium: small effect size; thick: medium effect size (see Appendix C).

By contrast, as a further characteristic of resource endowment, the past eco-innovative activities, \`DyEcoInnoPast´ (H3c), show a significant path to each of the three endogenous variables; the path coefficients to \`EcoGo-Reg´ and \`EcoInnoInt-Reg´ have the highest values in the inner model. The total influence of \`DyEcoInnoPast´ on \`EcoInnoInt-Reg´ is considerably higher than the direct influence, which might be attributed particularly to the indirect path via \`EcoGo-Reg´. This points to path dependencies and confirms H3c.

With regard to the effect of market factors, the results show a clear influence of the competitive conditions and eco-innovation because \`EcoCrisReg´ has a significant and medium sized path (in terms of effect size) to \`EcoInnoInt´, which confirms H5b.

(ii) With respect to the behavioural aspects related to innovation in general, a mixed picture emerges. In connection with H2a, the statistics show only one direct, weak and negative influence from `InnoAtt´ (H2a) to `EcoGo-Reg´. This is somewhat surprising because the items of the latent variable `EcoInnoInt-Reg´ were explicitly formulated in the survey with reference to general innovation activities (see table 1).[21] Insights from experimental behavioural economics research might offer an explanation; companies, or the relevant staff in companies, seem to undertake a type of 'mental accounting' in this regard (Thaler, 1999), keeping separate entries – cognitively (at least) and perhaps institutionally as well – for the two areas 'innovations in general' and 'specific environmental innovations'.[22] This is also indicated by the results about the influence of `InnoTrait´ (H3a). These show two direct but relatively weak paths to `EcoGo-Ov´ and `EcoGo-Reg´ (with a significance level of only 10%); the corresponding total effects are somewhat stronger but are still at a low level. Overall, therefore, hypotheses H3a and H3b are only confirmed to a limited extent.

As for Hypothesis 4, the statistics show the relevance of 'hard' economic targets as `ConstGo´ has a direct and an indirect effect on `EcoGo-Ov´ and `EcoGo-Reg´. However, there is no significant path to `EcoInnoInt-Reg´, and H4 is thus supported only partially. This finding contradicts the results of eco-innovation research; however, because the focus in that research does not include environmental goals as dependent and intermediate variables, the results are not comparable as a whole.

Hypothesis 5a, which addresses the expected performance of companies, can only be confirmed to a limited extent because the direct path that leads from `EcProg´ to `EcoInnoInt-Reg´ is significant only at a 10% level and so weak that the total effect is not significant. This contradicts the finding for H5b (see above); perhaps there is a mental accounting effect that responsible for the contradiction.[23]

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[21] Because one reason for this result might be that `InnoAtt´ does not exhibit any influence at all on innovative behaviour, a separate structural equation model was calculated, evaluating the influence of `InnoAtt´ on the intention to innovate in general (`InnoInt´; see Appendixes A, B, D); the results show that there is a significant influence with a medium-sized total effect, in terms of Cohen.

[22] To analyse this topic further, the correlations between `InnoInt´ and the three variables of the CEIS were evaluated, and none were significant (see Appendix B). Furthermore, a separate structural equation model was calculated that analysed the influence of `InnoInt´ on the CEIS. These results strengthen the assumption concerning mental accounting because no significant path could be found (see Appendix D).

[23] The influence of two control variables, the number of employees (`size´) and position on the supply chain (first tier or not (`Dy1st tier´)), in addition to the influence of `R&D´ in terms of the proportion of total number of employees working in R&D (see for the three variables Appendixes A, C), was also calculated separately. For the

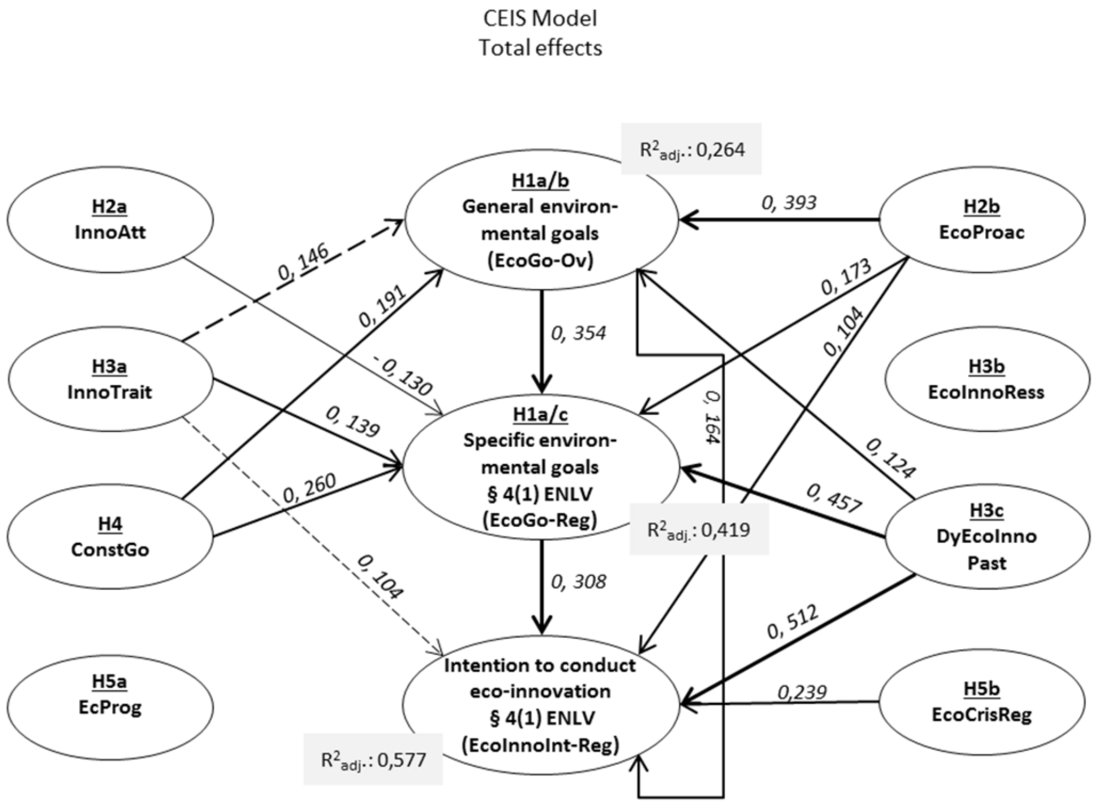

Figure 3: The CEIS model – total effects. The latent variables of the model are shown (see tab. 1) and only the significant paths (see Appendix B; the dotted lines indicate a level of significance of < 0.05 (two-tailed)). The thickness of the arrows reflects the total effect sizes and correspond to Cohen's classification – thin: no relevant effect; medium: small effect size; thick: medium effect size (see Appendix C).

7. Summary and implications

The aim of this study was to contribute to further development of eco-innovation research by applying the Carnegie School's 'initiation of innovation' behavioural model to the investigation of eco-innovative behaviour. The model of the 'Composed Eco-Initiation Structure' (CEIS) was conceived for this purpose, which was based conceptually on the initiation model and related to the implementation of article 4(1) of the ELVD by the German passenger vehicle supply industry. The nucleus of the CEIS is composed of the following three endogenous variables: general environment-related objectives, regulation-specific objectives, and eco-innovative intentions. The CEIS and the related hypotheses cover relevant aspects of the decision-making process that lead to eco-innovation and incorporate both intra-company and external factors. The concept was empirically tested on the basis of a quantitative survey of the target group in 2009; the analyses were conducted using the method of structural equa-

first two, no significant effects could be found, for the last, a significant negative effect could be observed but not constituting a relevant path to `EcoGo-Reg´ in terms of effect size.

tion modelling.

In summary, the concept of the CEIS proves to be empirically meaningful; a causal chain appears that travels from general environmental goals through regulation-specific goals to eco-innovative intentions. Moreover, behavioural determinants such as the ´green´ type of agent and creative abilities, in addition to external factors (here, in terms of the crisis of the automotive industry), prove to be relevant for the decision to conduct eco-innovation. Further relevant determinants are ´hard´ economic goals and past eco-innovative activities, in terms of path dependency.

However, only two of the six significant variables influencing the CEIS directly affect the intention to conduct eco-innovation – the total influence of the other variables is the result of indirect effects that result from the paths to and from the other two CEIS variables. This confirms the relevance of the concept of the CEIS; if only eco-innovations are considered and different levels of environmental goals are not taken into account, a loss of information may result, relevant causal effects may not be discovered and inconsistent results may appear insofar as effects of determinants are calculated that actually belong on the levels of goals.

With respect to further research, in light of the explanatory power of the CEIS, it might be worthwhile to investigate further behavioural aspects of the Carnegie School's initiation model that could not be pursued in this study (e.g., the level of aspiration). In addition, the model might be expanded to include current findings of behavioural economics (e.g., loss aversion and mental accounting; see below).

In the context of the present study, furthermore, several aspects suggest the need for further analyses. One issue is the effect of the specific resource endowment; another particularly important issue is the relatively low impact of behavioural traits that are related to innovation in general and expected corporate performance. It would be promising to examine further whether this is an instance of mental accounting in relation to innovation, as the results suggest. If this is the case, further research might investigate suitable strategies to overcome this effect and the respective implications for designing environmental policy measures.

As for the further implications of the present findings for regulatory design, the first conclusion to be drawn is that measures targeting singular aspects of the CEIS cannot sufficiently take into account the complexity of decision-making processes regarding eco-innovation.

Instead, environmental policy measures targeting several levels of the goal-setting and decision-making process might be more expedient. The present findings indicate, in principal, that explicitly naming eco-innovative goals in the framework of article 4(1) of the ELVD has led companies to establish goals related to the aspects mentioned. This shows the relevance of the stringency of regulations, as discussed by Porter and van der Linde (1995). Thus, a well-designed mix of instruments might link the general level (e.g., by targeting the self-concept as ´green´ actor) with a specific requirement (such as in article 4(1) of the ELVD).

Finally, it should be noted that the model of the CEIS developed here may be thought of as a proposal for the "integrated conceptual framework" of eco-innovation research called for by del Rio Gonzáles (2009, 871) – not least by linking the hypotheses with the state of eco-innovation research, ecologically motivated management research and innovation economics. The CEIS may unite various starting points and perspectives in eco-innovation research, allowing for further issue-based subjects to be taken into account, such as sectoral specificities or different types of eco-innovation as proposed by Kammerer (2009) and the OECD (2010).

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Appendix A. Supplement to the descriptive statistics

The questionnaire contained over 100 items, of which approximately 30% were used in the present study. Apart from the questions about turnover, employee numbers, R&D expenditure, etc., all questions in the questionnaire were scaled on a 6-point scale (end-point scale). All respective latent variables proposed in the model are based on reflective multi-items scales. The missing values were analysed by means of the 'Missing Value Analysis' tool in SPSS; in this process, the variable 'R&D costs as proportion of turnover' was excluded from the analysis because of missing values of over 30%; the remaining missing values had a maximum value of 6.5% per item, and the median of the number of missing values was 0.2%; these missing values were estimated by means of an EM estimation in SPSS. The variables that cover the number of employees and the proportion of the staff involved in R&D were addressed by logarithm because of the high levels of skewness and kurtosis (Hair et al. 2012).

Latent variable	Item	Question in questionnaire of the study	$\bar{x}$	$\tilde{x}$	sd
Size	LNSize	Number of employees (business year 2008, logarithmisiert)	1865	300	7000
R&D	LNR&D	Proportion of total number of employees working in R&D	20,2	5	56
Dy1st tier	1st tier	Dummy: suppliers on the first tier of the value chain	Yes: 34%; no: 66%		
(InnoInt)	InnoIntEx	To what extent will your company, in the next five years, conduct product innovations to be used in passenger cars	5,51	6,00	940
	InnoIntRs	To what extent will your company, in the next five years, expand resources for product innovations to be used in passenger cars.	4,45	5,00	1,342

Appendix B. Outer model indices

Latent variable coefficients

	EcoGo-Ov	EcoGo-Reg	EcoInnoInt-Reg	EcoProac	InnoTrait	ConstGo	InnoAtt	EcProg	EcoInnoRess	(InnoInt)
Composite reliability	.854	.888	.933	.826	.874	.861	.874	.878	.783	0.892
Cronbach's alpha	.773	.831	.857	.717	.818	.756	.816	.791	.582	0.757
Averange variance extracted	.595	.665	.875	.547	.583	.675	.591	.706	.548	0.805

Correlations among the latent variables and Fornall/Larcker criterium (in the diagonal)

	EcoGo-Ov	EcoGo-Reg	EcoInnoInt-Reg	EcoProac	InnoTrait	ConstGo	InnoAtt	EcoCrisReg	EcProg	EcoInnoRess
EcoGo-Ov	.771									
EcoGo-Reg	.477***	.815								
EcoInnoInt-Reg	.362***	.635***	.936							
EcoProac	.441***	.188**	.204***	.740						
InnoTrait	.284***	.179**	.190**	.310***	.764					
ConstGo	.228***	.291***	.168**	.078	.074	.822				
InnoAtt	.238***	.049	.134*	.397***	.388***	.200***	.769			
EcoCrisReg	.311***	.516***	.568***	.164**	.201***	.130*	.037	-		
EcProg	.041	-.025	.099	.160**	.184**	.133**	.301***	.086	0,840	
EcoInRess	-.006	.036	-.016	-.165	.029	-.153	-.172	.138	-.085	0,740
InnoInt	0.116	0.054	0.095	0.212	0.122	0.206	0.472	0.027	0.265	-0.219

Appendix C. Inner model indices

Coefficients of determination; Stone-Geisser-criterium ß (direct and total); effect size f^2 of ß (direct and total)

Endogeneous variables	Exogeneous variables	$R^2_{adj.}$ (L1)	R^2	R^2 without exogeneous variable	β direct	f^2 direct β	β total	f^2 total β
EcoGo-Ov	EcoProac	**0,237**	**0,280**	0,156	0,393***	0,173	0,393***	0,173
	DyEcoInnoPast			0,265	0,124**	0,022	0,124**	0,022
	EcoInnoRess			-	0,075	0	0,075	0
	InnoAtt			-	0,013	0,003	0,013	0,003
	InnoTrait			0,263	0,146*	0,041	0,146*	0,041
	ConstGo			0,246	0,191***	0,043	0,191***	0,043
	EcProg			-	-0,073	0,003	-0,073	0,003
EcoGo-Reg	EcoGo-Ov	**0,410**	**0,447**	0,357	0,354***	0,169	0,354***	0,169
	EcoProac			-	0,034	0,006	0,173***	0,033
	DyEcoInnoPast			0,284	0,414***	0,205	0,457***	0,227
	EcoInnoRess			-	0,031	0,001	0,058	0,002
	InnoAtt			0,435	- 0,135**	0,007	-0,13**	0,006
	InnoTrait			0,441	0,087*	0,016	0,139**	0,025
	ConstGo			0,415	0,193***	0,056	0,26***	0,076
	EcProg			-	-0,047	0,001	-0,073	0,002
EcoInnoInt-Reg	EcoGo-Ov	**0,562**	**0,595**	-	0,055	0,02	0,164***	0,059
	EcoGo-Reg			0,547	0,308***	0,196	0,308***	0,196
	EcoProac			-	0,029	0,006	0,104**	0,021
	DyEcoInnoPast			0,502	0,364***	0,228	0,512***	0,32
	EcoInnoRess			-	-0,063	0,001	-0,041	0,001
	EcoCrisReg			0,557	0,239***	0,136	0,239***	0,136
	InnoAtt			-	0,024	0,003	-0,015	0,002
	InnoTrait			-	0,023	0,004	0,074*	0,014
	ConstGo			-	-0,033	0,006	0,058	0,01
	EcProg			0,591	0,064*	0,006	0,037	0,004

Appendix D

Path coefficients and total effects of further variables

		LNSize	LNR&D	1st tier	EcGoRg	InnoAtt	
path coefficients	EcoGo-Ov	-.017	.073	.081	.464***		-0.003
	EcoGo-Reg	-.001	-.156***	-.003	.111*		0.019
	InnoInt-Reg	.006	-.012	.028	.011		-0.001
	InnoInt					0.472***	
total effects	EcoGo-Ov	.002	.011	.011	.256		0.000
	EcoGo-Reg	.001	.015	.003	.074		0.001
	InnoInt-Reg	.000	.001	.005	.023		0.000
	InnoInt					0.223	