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Integrated Product Policy and Environmental Product Innovations: An Empirical Analysis

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Non-technical Summary

The *European Commission* (*EC*) has recently stepped up its promotion of Integrated Product Policy (IPP). The aim of IPP, as defined by the *EC,* is to support the realisation of environmental product innovations and thus to achieve a broad reduction of all environmental impacts throughout a product's life cycle. The policy is based on the insight that all industrial goods cause environmental degradation in some way, whether from their manufacturing, use or disposal. IPP initiatives are largely due to the fact that traditional additive environmental protection measures are increasingly reaching their technical and economic limits. Moreover, consumption and disposal phases are also clearly growing in importance in comparison with the phases associated with the extraction of raw materials and the production process.

Bearing in mind the heterogeneity of products in general, IPP cannot of course consist simply of one general policy instrument. In fact, a whole variety of measures can be used to achieve IPP aims, e.g. standards or 'soft' environmental policy instruments such as voluntary agreements or environmental labelling – the latter of which is already being put into practice on a voluntary basis by a number of companies. Indeed, despite the *EC's Green Paper* on IPP which outlines proposals for the promotion of an IPP, we still only have a rudimentary understanding of the factors and environmental policy instruments which influence the environmental performance of products in general and thus of environmental product innovations in particular. There is therefore a need for empirical analyses with regard to the procedure of developing and designing IPP.

Our paper aims to fill this research gap and empirically examines the relationship between environmental organisational measures regarded as IPP measures by the *EC* and environmental product innovations. The study comprises both descriptive statistics on the correlations between IPP measures and environmental product innovations as well as an econometric analysis of the determinants of environmental product innovations applying binary and multinomial discrete choice models. The basis for the empirical analysis is a unique firm level data set of the German manufacturing sector that specifically focuses on environmental innovations.

According to the econometric analysis, the certification of environmental management systems has a significantly positive effect on environmental product innovations. Waste

disposal measures or product take-back systems appear to be an even more important driver of environmental product innovations. The econometric analysis also shows that other factors that have been suggested in the literature, such as environmental policy, technology push and market pull, as well as other specific company characteristics have a significantly positive influence on environmental product innovations.

The descriptive analysis also reveals that many environmental product innovators see themselves as being confronted with problems during the commercialisation of environmental products. According to statements from their own customers, particularly the higher price (and not lower quality or less reliability) of environmental products seems to be one of the major reasons for their low market performance. Therefore, economic rather than soft factors are the major obstacles to the commercial exploitation of environmental products and thus also to environmental product innovations. Left to their own devices, companies can do little to influence patterns of customer expenditures, i.e. increase their willingness to pay for environmentally beneficial products.

Instruments which use the price-mechanism or public demand can be regarded as potentially powerful and as stimulating innovation and improving the market performance of environmentally beneficial products. Examples are reduced VAT rates for products with an eco-label or a revision of public procurement. But it is precisely measures of this type which are not foreseen in the context of IPP as formulated by the EC. One main element in the strategy of the EU Commission is the stimulation of "continuous improvements" of products. The term "continuous improvement" remains vague, however, and includes neither quantitative targets nor a specification of what is meant by such improvements or of how they should be measured.

Hence, we conclude that soft environmental policy instruments such as activities regarding voluntary agreements or the certification of EMS may stimulate environmental product innovations to a certain extent. But the broad diffusion of environmentally innovative products from local or regional niche markets to international or global mass markets depends crucially on price and demand. Improvements in the relative prices of environmentally innovative products require tough environmental policy instruments such as reduced VAT rates for products with an eco-label or a revision of public procurement. There is a need to stimulate demand for environmental products by getting the prices economically (including external effects) right.

Integrated Product Policy and Environmental Product Innovations:
An Empirical Analysis

Katharina-Maria Rehfeld, Klaus Rennings and Andreas Ziegler[1]

Abstract

The European Commission has recently stepped up its promotion of the 'Integrated Product Policy'. The objective of the IPP is to support the realisation of environmental product innovations and thus to achieve a broad reduction of all environmental impacts throughout a product's life cycle. Based on a unique company level data set for the German manufacturing sector, this paper empirically examines the relationship between environmental organisational measures regarded as IPP measures by the European Commission and environmental product innovations. According to the econometric analysis, the certification of environmental management systems has a significantly positive effect on environmental product innovations. Waste disposal measures or product take-back systems appear to be an even more important driver of environmental product innovations. The econometric analysis also shows that other factors that have been suggested in the literature, such as environmental policy, technology push and market pull, as well as other specific company characteristics have a significantly positive influence on environmental product innovations. According to the descriptive analysis of environmental product innovators, economic aspects (i.e. higher prices) rather than soft factors appear to be the major obstacles to the commercial exploitation of environmental products and thus also to environmental product innovations.

Key-Words: Integrated Product Policy, Product Innovation, Environmental Innovation, Innovation Management, Technological Innovation, Discrete Choice Models
JEL-Classification: Q55, O32, O33, C25, Q01

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Integrated Product Policy and Environmental Product Innovations:
An Empirical Analysis

1 Introduction

The *European Commission* (*EC*) has recently stepped up its promotion of Integrated Product Policy (IPP). The aim of IPP, as defined by the *EC,* is to support the realisation of environmental product innovations and thus to achieve a broad reduction of all environmental impacts throughout a product's life cycle[2]. The policy is based on the insight that all industrial goods cause environmental degradation in some way, whether from their manufacturing, use or disposal. IPP initiatives are largely due to the fact that traditional additive environmental protection are increasingly reaching their technical and economic limits. Moreover, consumption and disposal phases are also clearly growing in importance in comparison with the phases associcated with the extraction of raw materials and the production process.

Bearing in mind the heterogeneity of products in general, IPP cannot of course consist simply of one general policy instrument. In fact, a whole variety of measures can be used to achieve IPP aims, e.g. standards or 'soft' environmental policy instruments such as voluntary agreements or environmental labelling – the latter of which is already being put into practice on a voluntary basis by a number of companies. Indeed, despite the *EC's Green Paper* on IPP which outlines proposals for the promotion of an IPP, we still only have a rudimentary understanding of the factors and environmental policy instruments which influence the environmental performance of products in general[3] and thus of environmental product innovations in particular. There is therefore a need for empirical analyses with regard to the procedure of developing and designing IPP.

Our paper aims to fill this research gap and empirically examines the relationship between environmental organisational measures regarded as IPP measures by the *EC* and environmental product innovations. The study comprises both descriptive statistics on the correlations between IPP measures and environmental product innovations as well as an econometric analysis of the determinants of environmental product innovations

[2] See *EU* (2001).

[3] See *EU* (2001, 2003).

applying binary and multinomial discrete choice models. The basis for the empirical analysis is a unique firm level data set of the German manufacturing sector that specifically focuses on environmental innovations.

The paper is organised as follows: Section 2 provides basic definitions and explains the conceptual framework. Section 3 describes the data set. After presenting some descriptive statistics in section 4, section 5 discusses the econometric analysis. Concluding remarks and policy implications are presented in the final section.

2 Definitions and Conceptual Framework

Based on the traditional understanding of innovations as defined in the *Oslo Manual* of the *OECD/Eurostat* (1997) that distinguishes mainly between product and process (as well as organisational) innovations in general, we use the following specific definitions of environmental and conventional product and process innovations: Product innovations in general enable the launch of improved or new products. Process innovations in general lead to decreased inputs, at a constant level of output. In contrast to conventional product and process innovations, environmental product and process innovations contribute to the avoidance or reduction of environmental burdens[4]. These can be realised with or without the explicit goal of limiting environmental damage. Environmental product and process innovations may therefore also be the product of company targets such as cost-cutting efforts or continuous quality improvement and may therefore combine environmental with business or consumer-oriented benefits[5].

Analysing and quantifying the determinants of innovations in general has been a challenging task in empirical economics for several decades. From the traditional industrial economics perspective, technological progress is explained at the microeconomic level of the individual market by means of factors from the supply and demand sides. As a result, discussion of the determinants of innovations in the previous literature was dominated for a long time by the so-called technology push and market pull theory. While *Schmookler* (1966) emphasised market pull factors and concluded that these are the major determinants of variations in the allocation of inventive effort, the technology push theory assumes that the main driving forces of progress are new technological op-

4 See *Kemp/Arundel* (1998).

5 See *Rennings/Zwick* (2002).

portunities[6]. Today, it seems to be generally accepted that the stimulus given by technology is particularly relevant for the initial stages of the life cycle of an innovation and market factors particularly for their further diffusion[7]. Focusing on the determinants of environmental innovations, supply and demand aspects must be complemented by another essential factor - environmental policy. Several theoretical papers have examined the linkages between environmental policy and innovations in general[8]. The aim of most of these studies has been to determine which environmental policy instruments (e.g. emissions charges, permits, standards) provide firms with the greatest incentive to realise innovations. In this context, this is referred to as the regulatory relation of environmental innovation or the regulatory push/pull factor[9]. However, the notion that environmental regulation can motivate firms to realise innovations has received only limited empirical support in the literature to date. This is largely due to the fact that it is very difficult to find appropriate indicators to measure environmental policy in an econometric approach. Even regulatory compliance expenditures, the only comprehensive measure of environmental regulatory burden, fall short of providing a truly exogenous measure as the level of these costs also depends on the nature of an industry's response to environmental regulation[10].

Furthermore, technology push, market pull and regulatory push/pull factors are complemented by other important company-specific determinants. Specific company characteristics mean that the point of departure for firms engaging in environmental innovation activities differs markedly, and these differences may explain the different intensity of the determinants and effects of environmental innovations. As the *OECD* criticises, only very few empirical studies have to date focused on the linkages between other specific company characteristics and environmental performance in general[11] and thus environmental product innovations in particular.

Finally, in its *Green Paper* on IPP, the *EC* assumes that some environmental organisational measures are capable of promoting environmental product innovations. In this

[6] See e.g. *Rosenberg* (1974).

[7] See *Pavitt* (1984).

[8] See for an overview *Jaffe* et al. (2002).

[9] See *Rennings* (2000).

[10] See *Jaffe*/*Palmer* (1997).

[11] See *OECD* (2001).

paper, we analyse five such measures for the German manufacturing sector: environmental criteria in product planning and development, certified environmental management systems (EMS), life cycle assessment activities of own products, waste disposal or take-back systems of own products and environmental labelling. We therefore focus on the relationship between these organisational IPP measures and technological environmental product innovations. We carry out this examination by descriptive statistics on correlations and by an econometric analysis applying binary and multinomial discrete choice models.

Overall, the empirical literature on the determinants of environmental innovations is sparse. Much of this literature is either anecdotal or based on limited industry case studies. Very few studies apply econometric approaches. *Arora*/*Cason* (1995) e.g. investigated why firms voluntarily participate in pollution prevention programmes. *Henriques*/*Sadorsky* (1996), *DeCanio*/*Watkins* (1998), *Blum-Kusterer*/*Hussain* (2001) and *Nakamura* et al. (2001) examine the determinants of the certification of EMS by *ISO 14001* and the commitment to environmental-related company targets. However, these studies focus on innovative organisational measures. In contrast, *Green* et al. (1994) empirically analysed the characteristics of firms in the UK participating voluntarily in a public programme that aimed at the promotion of environmental product and process innovations. *Cleff*/*Rennings* (1999) and *Rennings* et al. (2003) focused on the determinants of environmental product and process innovations in their econometric analyses. Indeed, the conclusions drawn from the latter three studies are limited to some extent given that the relevant sample only included environmentally innovative companies.

3 Data

In the run-up to our empirical analysis, six case studies with German companies belonging to the manufacturing sector were conducted in winter/spring 2002/2003. For these case studies, environmental reports as well as other company-specific documents on environmentally related activities were analysed and the representatives of the respective firms responsible for environmental protection and/or production were interviewed[12]. The results of these case studies contributed to a telephone survey, especially

[12] See *Türpitz* (2004).

with regard to questionnaire design and an initial specification of possible determinants of environmental product innovations.

The telephone survey was conducted at the *Centre for European Economic Research (ZEW)* in *Mannheim*, *Germany*, in summer/autumn 2003. The population was the universe of all German manufacturing companies (*NACE*-Codes 15-37) with 50 or more employees. 2998 addresses were drawn from a stratified representative sample considering two classes of company size (less than 200 and at least 200 employees), two regions (*Western* and *Eastern Germany*), and eleven industries. The corresponding companies were notified in advance by mail of the forthcoming survey. The telephone survey targeted responsible production managers as case studies have shown that these people are the most competent respondents to the set of questions we wished to pose (R&D-Manager, Environmental Manager, General Manager).

The survey was pre-tested for clarity and practicability with several companies that had also been notified in advance. Interviews were conducted by highly-experienced telephone interviewers. The survey targeted 2511 companies. Of these 2511 companies, 112 could not be reached, 1811 refused to participate, and 588 participated in the survey. Thus, of the 2399 companies reached, 24.5% participated in the survey. This is a fairly typical participation rate for firm-related telephone surveys in *Germany*. With regard to the aforementioned two classes of company size, two regions, and eleven industries, tests were carried out to determine whether the corresponding shares for these 588 companies comply with the shares from the population. The appropriate two-tailed tests revealed that the underlying null hypotheses can never be rejected at the 10% level of significance.

In order to identify the companies' innovation activities, the questionnaire named potential areas for innovation under which the companies could classify their activities. The aforementioned four different types of innovation were distinguished: conventional product innovations, conventional process innovations, environmental product innovations and environmental process innovations. To avoid double counts, an environmental innovation is regarded as a special rather than conventional type of innovation. Thus, the realisation of a conventional product or process innovation refers simply to an activity that does not contribute to the avoidance or reduction of environmental burden. Furthermore, with regard to these innovations, we asked the companies to distinguish between innovations they had already realised in the three years prior to the survey, i.e. between 2001 and 2003, and those they plan to realise in the forthcoming three years, i.e. between 2003 and 2005.

Table 1 gives an overview of the innovativeness of the 588 participating companies and shows that only 37.2% have realised an environmental product innovation. In contrast, the number of companies having realised environmental process innovations is much higher with 69.9% of companies having realised this type of environmental innovation between 2001 and 2003. This might be due to the fact that, in the past, environmental policy mainly focused on process-related environmental burdens and neglected product-related aspects to some extent. Strikingly, 64.5% of companies have realised a conventional product innovation. This is almost twice as many as the number of companies which have realised an environmental product innovation. Finally, 67.5% have realised a conventional process innovation, and this is approximately the share of companies having realised an environmental process innovation.

Table 1 also shows the relationship between innovations realised between 2001 and 2003 and innovations planned for the period 2003 to 2005. Analysing these linkages more closely, it is apparent that there is a very high correlation for a certain kind of innovation between the past and the future. The correlation coefficients vary between 0.650 (for conventional process innovations) and 0.760 (for conventional product innovations). According to the appropriate tests, the null hypothesis that the correlation coefficient is zero can thus be rejected at the 1% level of significance for all four types of innovations. This means that if a company has realised a certain type of innovation in the past, the probability that it will continue such an activity in the future is very high.

4 Peculiarities of Environmental Product Innovators

4.1 IPP Measures and environmental product innovations

In order to obtain information on the relationship between IPP measures and environmental product innovations, some descriptive statistics are analysed in the first step. Differentiating between various environmental organisational measures regarded as IPP measures by the *EC*, we asked all the companies whether they currently apply the following measures: environmental criteria in product planning and development (=*environmental criteria*), certification of EMS to international standards *ISO 14001* or

EMAS of at least one facility (=*ISO 14001 or EMAS*), waste disposal or take-back systems of products (=*waste disposal*), life cycle assessment activities (=*life cycle assessment*), environmental labelling (=*environmental labelling*). Of the 588 companies which participated in the survey, we distinguished between the 219 companies which had realised an environmental product innovation in the period 2001 to 2003 (=*environmental product innovators*) and the 342 companies which had not realised an environmental product innovation in this period (=*non-environmental product innovators*).

As can be seen in *Table 2*, environmental criteria in product planning and development are the most common IPP measures. 74.9% of the companies which had realised an environmental product innovation implemented this measure. In contrast, this measure was applied by 43.6% of the non-environmental product innovators. Comparing all IPP measures, the application shares differ most between environmental and non-environmental product innovators for this first measure. Thus, activities affecting the development process of products in an early state are strongly related to environmental product innovations.

Although an EMS in its current form is not strongly linked to product design issues[13], it can lead to an increasing awareness of environmental aspects within a firm[14]. According to *Table 2*, 40.2% of all environmental product innovators and only 21.3% of all non-environmental product innovators are certified to the international *ISO 14001* standard or to the European Environmental Management and Audit Scheme *EMAS*. This result also suggests a positive relationship between EMS certification and environmental product innovations.

Approximately half (50.7%) of the environmental product innovators implement measures relating to waste disposal or product take-back. In contrast, these measures are applied by a mere 33.3% of all non-environmental product innovators. It is important to note that the legal requirements for producer responsibility demand that manufacturers take back products from consumers at the end of the utilisation phase. This does not, however, imply that products necessarily have to be taken back physically. It is sufficient that firms bear the take-back costs of waste disposal or recycling. However, one fundamental problem is that the overall costs of waste disposal cannot be easily attrib-

[13] See *Rennings et al. (2003)*.

[14] See *EU* (2001).

uted to individual products. Nevertheless, according to *Table 2*, environmental product innovations are positively correlated with the continued interest of the manufacturer in his products even after the utilisation phase.

Life cycle assessment activities only seem to play a minor role for environmental product innovators as only 29.2% of these companies apply this measure. Indeed, the corresponding share (9.6%) for non-environmental product innovators is much smaller so that the difference between the application shares for environmental and non-environmental innovators is greater than the corresponding differences regarding the certification for EMS or the waste disposal or redemption of own products. In this regard, it has also been examined whether the share of life cycle assessment activities for environmental product innovators is really significantly greater than the corresponding share for non-environmental product innovators. The appropriate one-tailed test shows that this (alternative) hypothesis can be proved at the 1% level of significance.

This test result also holds true for the IPP measures *environmental criteria*, *ISO 14001 or EMAS* and *waste disposal*. In contrast, the underlying null hypothesis could not be rejected at the 10% level of significance regarding environmental labelling. This measure appears to be seldom used by either environmental product innovators (12.3%) or non-environmental product innovators (8.2%). This result supports the view that with regard to environmental labelling, the time and money that need to be invested discourage their use.

4.2 Environmental Policy and Environmental Product Innovations

With regard to environmental policy, we asked all those companies which had realised at least one type of (environmental or conventional) innovation about the importance of compliance with existing and future legal requirements for innovations in general between 2001 and 2003. In the following, we distinguish between the 219 companies which had realised an environmental product innovation between 2001 and 2003 (=*environmental product innovators*) and the 321 companies which had realised an innovation other than an environmental product innovation in the same period (=*non-environmental product innovators*).

Table 3 shows that environmental policy appears to be positively related to environmental product innovations. 68.9% of all those companies which had realised an environmental product innovation consider compliance with existing and future legal requirements as an important innovation goal. In contrast, the corresponding share for companies which had not realised an environmental product innovation is only 53.3%. An examination was also conducted to determine whether the share for environmental product innovators is significantly higher than the share for non-environmental product innovators. The appropriate one-tailed test shows that this (alternative) hypothesis can be proved at the 1% level of significance. This result corresponds to earlier findings obtained in the case studies that companies that anticipate future legal requirements tend to realise environmental product at early stage given that these activities will generate lower costs in the medium and long term[15].

4.3 Obstacles to commercial exploitation

The conventional view is that environmental products often have strong commercialisation problems. To analyse this, all 219 environmental product innovators between 2001 and 2003 were asked whether they agree or disagree with the following three statements from their own customers (for the period from 2001 to 2003): Environmental products are *"more expensive"*, *"of lower quality"* or *"less reliable"* than corresponding conventional products. *Table 4* shows that 53.0% of these companies report that their own customers state that environmental products are more expensive than conventional substitutes. Therefore, price might be one explanation for weak market performance. In contrast, there is almost no confirmation (10.0%) of the statement that environmental products are of lower quality than conventional substitutes. This indicates that environmental product innovators often regard improved environmental performance of products as one component part of comprehensive quality management and strategy[16]. Finally, only 24.7% of the environmental product innovators agreed with the statement that environmental products are less reliable than corresponding conventional products. Thus, economic rather than 'soft' factors appear to be the major obstacles to the commercial exploitation of environmental products and therefore also to environmental product innovations.

[15] See *Türpitz* (2004).

[16] See *Türpitz* (2004).

5 Econometric Analysis

5.1 Models and Variables

The descriptive analysis in section 4 examines correlations between IPP measures or environmental policy and environmental product innovations. Indeed, the specific effects of IPP measures and environmental policy on environmental product innovations separated from the influence of other factors can only be analysed by econometric approaches. In the following, we apply binary and multinomial discrete choice models to examine the determinants of environmental product innovations. Note that future and not past environmental innovations are used in this econometric analysis. This is due to the fact that e.g. IPP measures may depend on environmental innovations in the past which makes these explanatory variables endogenous. This problem can be minimized by including lagged explanatory variables. In this respect, it is striking that according to section 3, the correlations between specific types of innovations realised between 2001 and 2003 as well as those planned between 2003 and 2005 are strongly positive.

Overall, 371 of the 588 companies which participated in the survey are included in the econometric analysis. As well as companies for which data on the dependent or explanatory variables was unavailable, we also excluded companies founded or organisationally modified in the years 2002 or 2003 as many explanatory variables refer to the period from 2001 to 2003. Only companies which realised at least one type of innovation from 2001 to 2003 were included in the analysis. This is due to the fact that the question relating to the environmental policy variable was only put to innovating firms. With regard to the aforementioned classes of company size, regions and industries, an examination was again performed to determine whether the corresponding shares for these 371 innovators comply with the shares for the population. The appropriate two-tailed tests showed that the underlying null hypotheses can never be rejected at the 10% level of significance.

In the first step, a binary logit model is applied. The main choice alternative (i.e. innovation type) *ENV-PRODUCT-INNOVATION* comprises an environmental product innovation. Indeed, the basic choice alternative may not be an environmental innovation at all or may simply be an environmental process innovation or a conventional product or process innovation. It cannot be an environmental product innovation, but otherwise the basic choice alternative is fairly heterogeneous. As a result, the binary logit analysis cannot examine the determinants of environmental product innovations compared with the absence of environmental innovations at all.

However, such an analysis is possible with multinomial logit models[17] by constructing suitable mutually exclusive choice alternatives (i.e. innovation types). In this paper, a logit model which includes three alternatives is considered. It includes the main choice alternatives E*NV-PRODUCT-INNOVATION* and *ONLY-ENV-PROCESS-INNOVATION*. The first choice alternative comprises an environmental product innovation as in the binary logit model. The second alternative contains an environmental process innovation but not an environmental product innovation. The basic choice alternative *NO-ENV-INNOVATION* comprises no environmental innovation at all and thus only a conventional product or process innovation. Conceptually, we assume in both the multinomial and binary logit model that a company will choose the innovation type promising the highest profit.

Regarding the specific choice alternatives, of the 371 companies, 155 (=41.8%) plan to realise an environmental product innovation, 140 (=37.7%) plan to realise an environmental process innovation but not an environmental product innovation and 76 (=20.5%) plan to realise no environmental innovation at all. Note that the first choice alternative can comprise only an environmental product innovation as well as both an environmental product and a process innovation. In fact, only 27 (=7.3%) companies included in the econometric analysis will realise solely an environmental product innovation. This indicates that it is likely that environmental product innovations also imply changes in the production process. Consequently, 128 (=34.5%) companies plan to realise both an environmental product and a process innovation. In contrast, the realisation of only an environmental process innovation is more common as environmental process innovations are realised within the firm and need not necessarily lead to environmental product innovations.

Table 5 gives an overview of the major explanatory variables both in the binary and multinomial logit models. According to the assumption that environmental product innovations are triggered by IPP measures, environmental policy, technology push and market pull factors as well as by other specific company characteristics, we have divided the explanatory variables into these five major categories. The dummy variables

[17] See e.g. *Greene* (2000).

EMS, *DISPOSAL*, *LCA* and *LABEL* regarding the IPP measures and the environmental policy variable *LEG* are based on the questions that are discussed in the descriptive analysis in section 4. We have also experimented with the inclusion of a dummy variable based on the IPP measure *environmental criteria*. However, the causality of the relationship between this measure and environmental product innovations is not clear. Due to the potential endogeneity problem, we have excluded this explanatory variable from the analysis.

It might be argued that the application of one IPP measure often leads to the application of other IPP measures so that the four analysed dummy variables are strongly positively linked to each other. If this holds true, the use of all four IPP measures could lead to multicollinearity problems in the econometric analysis. But the correlation coefficients between variables *EMS*, *DISPOSAL*, *LCA* and *LABEL* are rather small or moderate and vary between 0.018 (for *EMS* and *DISPOSAL*) and 0.270 (for *EMS* and *LCA*).

The research and development activities of a firm seem to be a good indicator for technology push variables. We therefore asked the companies whether they have performed such activities in 2002 and include the corresponding dummy variable *R&D* in our analysis. Concerning market pull variables, we have included the dummy variable *CUST* that takes the value one if customer satisfaction is an important factor to deliver competitive advantages on the most important sales market of the firm between 2001 and 2003. Another market pull variable is the export activity of a firm that is often used as an indicator for a firm's market orientation[18]. Firms with high global market orientation are regarded as more likely to realise product and process innovations in general than firms which mainly operate on local markets – probably owing to tougher competition on international markets. Thus, we also include the dummy variable *EXP* that takes the value one if a firm has exported in 2002.

One further specific company characteristic we have included is the dummy variable *ISO 9001* that takes the value one if at least one facility of the firm is currently certified to *ISO 9001*. According to the results by *Montabon* et al. (2000), certified quality management systems such as *ISO 9001* can have a positive influence on commitment to environmentally-related company targets as well as innovations. Furthermore, our analysis also contains variables indicating the size and age of a company. In accordance

[18] See e.g. *Ebling/Janz* (1999).

with the first *Schumpeterian* hypothesis, larger firms have a higher probability of being innovative than smaller firms since they have more of the complementary financial, physical and commercial resources that are necessary for innovations[19]. In order to estimate the influence of a company's size we use the variable *SIZE* which is the logarithm of the number of salaried employees at the end of 2002. According to *Diederen* et al. (2002), a company's age has a negative influence on innovations. However, our case studies in the run-up to this study indicated that older firms have developed a relatively broad knowledge base over time which can lead to the realisation of further environmental innovations. In our analysis, the variables *1_AGE* and *1_AGE2* indicate the reciprocal and the squared reciprocal of the present firm age (in each case multiplied by ten due to dimensionality). Note that we define firm age as the time since foundation or last modification of the firm.

Finally, structural differences between sectors and regions have been accounted for by including ten sector dummies and one dummy for *Western Germany*. Note that these explanatory dummy variables are included in both the binary and multinomial logit estimation, even though the estimates of the corresponding parameters are not displayed in the following for brevity. All these maximum likelihood estimations have been performed with the software package *STATA* applying the so-called robust estimation of the standard deviation of the parameter estimates to calculate the z-statistics[20] .

5.2 Results

Table 6 reports the estimation results in the binary and in the multinomial logit model which are qualitatively rather similar in both models concerning the determinants of environmental product innovations (i.e. of *ENV-PRODUCT-INNOVATION*). Thus, splitting the basic choice alternative in the binary discrete choice model into two choice alternatives in the multinomial discrete choice model does not lead to fundamentally different results. As a consequence, most explanatory variables do not have a significant effect on environmental process innovations only compared with the absence of environmental innovations at all in the multinomial logit model.

[19] See also *Janz* et al. (2003).

[20] See *White* (1982).

The weakly significant positive influence of EMS certification to *ISO 14001 or EMAS* on *ENV-PRODUCT-INNOVATION* in the binary logit model acquires greater significance in the multinomial logit model, however, and it would appear that a certified EMS induces companies to review their existing procedures for potential improvements with respect to environmental product innovations. Measures concerning waste disposal or take-back systems for own products are even more important. *DISPOSAL* has a positive effect on *ENV-PRODUCT-INNOVATION* at the 1% level of significance in both the binary and the multinomial logit model. Obviously, if a firm has a continued interest in its own products even after the utilisation phase, the probability of recycling-friendly environmental product innovations increases. In contrast, environmental labelling of own products and life cycle assessment activities have no significant effect on environmental product innovations. Concerning *LCA*, this estimation result is rather surprising since the descriptive analysis in section 4 shows a strong relationship between life cycle assessment activities and environmental product innovations. But this positive correlation seems to be covered by other factors.

The environmental policy variable *LEG* has a weakly significant positive effect on *ENV-PRODUCT-INNOVATION* in both the binary and the multinomial logit model. Thus, in accordance with the aforementioned drivers for environmental product innovations, environmental policy would appear to offer additional impetus, even if the effect is rather weak. These results suggest that environmental policy has a positive effect on the realisation of both environmental product and process innovations together instead of on only one type of environmental innovation given that, in addition, *LEG* has no significant influence on *ONLY-ENV-PROCESS-INNOVATION* in the multinomial logit model.

With regard to the variables *R&D*, *CUST* and *EXP*, both technology push and market pull appear to have an influence on environmental product innovations. *R&D* has a weakly and *CUST* has a strongly significant positive effect on *ENV-PRODUCT-INNOVATION* in both the binary and the multinomial logit model. In a sense this confirms the view that environmental product innovations really need both kinds of stimuli. Indeed, the positive effect of our technology push variable is only weakly statistically secured. Furthermore, the market pull variable *EXP* has no significant effect on environmental product innovations. Thus, according to our analysis, export activities do not seem to be an important explanatory factor for environmental product innovation as has been shown for innovations in general. Most environmentally friendly products still appear to be marketed on regional or national niche markets rather than on global markets.

Certification to *ISO 9001* does not appear to have a significant effect on environmental product innovations. Thus, it seems that on the one hand certified general management quality standards are a less important factor for environmental product innovations than specific certified EMS or specific environmental organisational measures. On the other hand, this certification also seems to be less important with regard to environmental product innovation compared with innovations in general. In contrast and in line with other findings regarding innovations in general, *SIZE* has a significant positive effect on environmental product innovations, even if the significance level is rather high in the binary logit model. Finally, company age has a strongly significant effect. Both the binary and the multinomial logit model show a U-shaped influence of company age on *ENV-PRODUCT-INNOVATION*. Therefore, it seems that there is often a threshold that must be passed before a company is able to realise environmental product innovations again. As a result, company age is not an obstacle. In contrast, more mature firms might have developed a broad internal knowledge base which can lead to the realisation of further environmental product innovations.

6 Concluding Remarks and Policy Implications

This paper empirically examines the relationship between environmental organisational measures regarded as IPP measures by the *EC* and environmental product innovations in the German manufacturing sector. The econometric analysis shows that the certification of EMS to *ISO 14001* or *EMAS* has a significantly positive effect on environmental product innovations. A certified EMS would therefore appear to induce companies to review their existing procedures for potential improvements to environmental product innovations. Certified companies thus seem to regard environmental protection as an integral element of their company-wide strategy. Waste disposal measures and measures relating to the redemption of own products appear to be even more important drivers for environmental product innovations. One explanation might be that manufacturers not only determine the basic utilisation and recycling features of their products, but can also influence recycling and waste treatment costs during the product planning and development phases. Thus, if a manufacturer has a continued interest in his product even after the utilisation phase, recycling-friendly environmental product innovations are far more probable. How easy or difficult it is to recover raw or residual materials from consumer goods after use and/or to reduce emissions during waste treatment depends largely on the specific products. In contrast, life cycle assessment activities and environmental labelling only play a minor role for environmental product innovations since the corresponding variables have no significant effect.

The discussion of the determinants of environmental innovations suggests four further factors in addition to IPP measures: Environmental policy, technology push and market pull factors as well as other specific company characteristics. This notion can be proved by our econometric analysis. For example, environmental policy seems to be a driver for environmental product innovations, even if the positive effect is rather weak. However, technology push (i.e. R&D activities), market pull (i.e. customer satisfaction as an important factor to deliver competitive advantages on the most important sales market) and other specific company characteristics (i.e. company size and age) that have only been examined very little in empirical studies on environmental innovations so far also have a significant influence on environmental product innovations.

With regard to both types of environmental innovation, the descriptive analysis shows that the number of environmental process innovations is much higher. In this context, environmental product innovations are closely linked with environmental process innovations in such a way that changes in the production process are typically induced by product changes. Thus, the *EC's* demand for an IPP geared to the whole life cycle of a product reflects a realistic picture of what is going on in firms.

The descriptive analysis also reveals that many environmental product innovators see themselves as being confronted with problems during the commercialisation of environmental products. According to statements from their own customers, particularly the higher price (and not lower quality or less reliability) of environmental products seems to be one of the major reasons for their low market performance. Therefore, economic rather than soft factors are the major obstacles to the commercial exploitation of environmental products and thus also to environmental product innovations. Left to their own devices, companies can do little to influence patterns of customer expenditures, i.e. increase their willingness to pay for environmentally beneficial products.

Instruments which use the price-mechanism can be regarded as potentially powerful and as stimulating innovation and improving the market performance of environmentally beneficial products. Examples are reduced VAT rates for products with an eco-label or a revision of public procurement. But it is precisely measures of this type which are not foreseen in the context of IPP as formulated by the EC. One main element in the strategy of the EU Commission is the stimulation of "continuous improvements" of products. The term "continuous improvement" remains vague, however, and includes neither quantitative targets nor a specification of what is meant by such improvements or of how they should be measured.

Hence, we conclude that soft environmental policy instruments such as activities regarding voluntary agreements or the certification of EMS may stimulate environmental product innovations to a certain extent. But the broad diffusion of environmentally innovative products from local or regional niche markets to international or global mass markets depends crucially on price. Improvements in the relative prices of environmentally innovative products require tough environmental policy instruments such as reduced VAT rates for products with an eco-label or a revision of public procurement. There is a need to stimulate demand for environmental products by getting the prices economically (including external effects) right. This could also stimulate companies to conduct environmental labelling of own products to a larger extent than is apparent in our descriptive analysis. But there is also a need to promote life cycle assessment activities. Given its complexity, this IPP measure obviously cannot be applied on a broad front at the present time.

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Table 1: Numbers and shares of companies which have realised or plan to realise different types of innovations (based on all companies taking part in the survey)

Between 2001 and 2003						
	Realised		**Not realised**		**No answer**	
Environmental product innovation	219	37.2%	342	58.2%	27	4.6%
Environmental process innovation	411	69.9%	164	27.9%	13	2.2%
Conventional product innovation	379	64.5%	197	33.5%	12	2.0%
Conventional process innovation	397	67.5%	180	30.6%	11	1.9%
Between 2003 and 2005						
	Planned to realise		**No plans for realisation**		**No answer**	
Environmental product innovation	224	38.1%	328	55.8%	36	6.1%
Environmental process innovation	370	62.9%	198	33.7%	20	3.4%
Conventional product innovation	393	66.8%	175	29.8%	20	3.4%
Conventional process innovation	382	65.0%	183	31.1%	23	3.9%

Table 2: Shares of companies applying different IPP measures (based on all companies taking part in the survey)

IPP measures	**Environmental product innovators**		
	Applied	**Not applied**	**No answer**
Environmental criteria	74.9%	24.7%	0.5%
ISO 14001 or EMAS	40.2%	57.1%	2.7%
Waste disposal	50.7%	48.4%	0.9%
Life cycle assessment	29.2%	69.4%	1.4%
Environmental labelling	12.3%	85.4%	2.3%
IPP measures	**Non-environmental product innovators**		
	Applied	**Not applied**	**No answer**
Environmental criteria	43.6%	54.7%	1.8%
ISO 14001 or EMAS	21.3%	75.7%	2.9%
Waste disposal	33.3%	65.8%	0.9%
Life cycle assessment	9.6%	87.7%	2.6%
Environmental labelling	8.2%	91.2%	0.6%

Table 3: Shares of companies that regard compliance with existing and future legal requirements as an important innovation goal (based on environmental product innovators and non-environmental product innovators)

	Environmental product innovators			
	Important	**Average important**	**Less important**	**No answer**
Importance of compliance with existing and future legal requirements for innovations	68.9%	20.1%	10.0%	0.9%
	Non-environmental product innovators			
	Important	**Average important**	**Less important**	**No answer**
Importance of compliance with existing and future legal requirements for innovations	53.3%	23.1%	19.9%	3.7%

Table 4: Shares of companies agreeing to statements from their own customers regarding environmental products compared with conventional substitutes (based on environmental product innovators)

	Agreed	**Not agreed**	**No answer**
"More expensive"	53.0%	42.0%	5.0%
"Of lower quality"	10.0%	84.9%	5.0%
"Less reliable"	24.7%	68.0%	7.3%

Table 5: Description of the explanatory variables

IPP measure variables	
EMS	One if at least one facility of the firm has an EMS certified to ISO 14001or EMAS at present, otherwise zero
DISPOSAL	One if the firm carries out measures relating to the waste disposal or redemption of own products at present, otherwise zero
LCA	One if the firm performs life cycle assessment activities at present, otherwise zero
LABEL	One if the firm conducts environmental labeling of own products at present, otherwise zero
Environmental policy variable	
LEG	One if the firm considers compliance with existing and future legal requirements as an important innovation goal between 2001 and 2003, otherwise zero
Technology push variable	
R&D	One if the firm has carried out R&D-activities in 2002, otherwise zero
Market pull variables	
CUST	One if customer satisfaction is an important factor to deliver competitive advantages on the most important sales market of the firm between 2001 and 2003, otherwise zero
EXP	One if the firm has exported in 2002, otherwise zero
Other specific company characteristics	
ISO 9001	One if at least one facility of the firm is certified according to ISO9001 at present, otherwise zero
SIZE	Logarithm of the number of salaried employees of the firm at the end of 2002
1_AGE	Reciprocal of the present age of the firm (multiplied by ten)
1_AGE2	Squared reciprocal of the present age of the firm (multiplied by ten)

Table 6: Parameter estimates in the binary and multinomial logit model

	Binary logit model	**Multinomial logit model (Basic choice alternative: NO-ENV-INNOVATION)**	
	ENV-PRODUCT-INNOVATION	**ENV-PRODUCT-INNOVATION**	**ONLY-ENV-PROCESS-INNOVATION**
EMS	0.500* (1.79)	1.029** (2.48)	0.697* (1.67)
DISPOSAL	0.747*** (2.949)	1.014*** (2.83)	0.387 (1.13)
LCA	0.492 (1.51)	0.215 (0.44)	-0.409 (-0.77)
LABEL	-0.027 (-0.07)	0.576 (0.88)	0.794 (1.20)
LEG	0.466* (1.83)	0.649* (1.90)	0.240 (0.75)
R&D	0.665* (1.83)	0.830* (1.81)	0.226 (0.55)
CUST	1.310** (2.46)	1.632** (2.50)	0.454 (0.96)
EXP	-0.049 (-0.11)	-0.104 (-0.20)	-0.062 (-0.14)
ISO9001	0.122 (0.42)	0.439 (1.15)	0.486 (1.37)
SIZE	0.226* (1.76)	0.452** (2.51)	0.325* (1.92)
1_AGE	-0.614** (-2.12)	-1.364*** (-3.30)	-1.032** (-2.56)
1_AGE2	1.465** (2.41)	3.267*** (3.40)	2.406** (2.54)
CONSTANT	-3.520*** (-3.19)	-3.684** (-2.52)	-1.214 (-1.05)

Note:
The estimations include ten sector dummies and one dummy for *Western Germany* and are based on 371 observations (innovating companies).
Z-statistics in parentheses. * (**, ***) means that the null hypothesis that the appropriate parameter is zero can be rejected at the 10% (5%, 1%) level of significance (according to the corresponding two-tailed test).