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The Impact of Resource Efficiency Measures on Performance in Small and Medium-sized Enterprises

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Jens Horbach[1]

The Impact of Resource Efficiency Measures on Performance in Small and Medium-sized Enterprises

Abstract

The profitability of green investment is crucial for the diffusion of the resulting technologies but the knowledge about these effects is still limited. Positive performance effects may be based on cost savings stemming from the introduction of cleaner production processes connected with lower material and/or energy use. The present paper empirically analyzes the effects of environmentally active behavior on the performance of a firm. The analysis is based on the 2013 wave of the Eurobarometer data for small and medium-sized firms (SME´s). The analysis for SME´s seems to be interesting because small firms might be especially affected by the costs of environmental measures as the introduction of resource efficiency measures are costly in the short run. The results of a bivariate probit model show that a high amount in investment in resource efficiency measures triggers the overall performance of the firm. A high self-perceived greenness of the firm and a high share of green employment are positively correlated to performance. In fact, not all measures in improving resource efficiency are connected with positive performance effects: An increased use of renewables leads to a higher performance whereas measures to reduce water consumption are negatively correlated to turnover development.

JEL Classification: C35, O33, Q55

Keywords: Eco-innovation; bivariate probit model; SME

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1. Introduction

The effects of environmental measures on firm growth and productivity are more and more in the focus because a growing number of studies show positive effects contrary to the "traditional" view that environmental activities only raise production costs. The profitability of green investment is crucial for the diffusion of the resulting technologies but the knowledge about these effects is still limited. Positive performance effects may be based on cost savings stemming from the introduction of cleaner production processes connected with lower material and/or energy use. A further positive effect has been raised by Porter and van der Linde (1995). Following the Porter hypothesis, regulation-induced early introduction of environmental products may lead to first-mover advantages and to an improvement of a firm´s competitiveness thus leading to a better performance.

The present paper empirically analyzes the effects of environmentally active behavior on the performance of a firm. The analysis is based on the 2013 wave of the Eurobarometer data for small and medium-sized firms (SME´s). The analysis for SME´s seems to be interesting because small firms might be especially affected by the costs of environmental measures as the introduction of resource efficiency measures are costly in the short run. For SME´s with limited financial possibilities these short run costs may constitute an important barrier to invest in cleaner technologies despite considerable cost saving effects in the long run. On the other side, it might be possible that especially "young pioneers" confirm the validity of the Porter hypothesis. Many examples in the past show that young and small firms are often more likely developing totally new ideas and products whereas big and established firms are not able to change their innovation paths. Therefore, first mover advantages are often based on the activities of small and medium-sized firms. The problem is that the small firms might be less able to bear the risks of developing new products. A strict environmental regulation in a country may create opportunities and demand security thus reducing the risks for SME´s. The Eurobarometer data also allows answering the question which environmental and resource-related measures lead to positive performance effects. Typical end-of-pipe measures such as water purification by sewage treatment plants might lead to negative performance effects whereas the introduction of energy saving measures might increase a firm´s performance.

The paper is organized as follows. Section 2 summarizes the main theoretical considerations on the relationship of eco-innovations and performance and the empirical literature. In Section 3.1, the Eurobarometer data basis and main descriptive results are presented. Section 3.2

shows the results of bivariate probit models analyzing the effects of resource efficiency measures on turnover development and self-perceived profitability.

2. The effects of eco-innovations on performance: Theoretical considerations and literature overview

Whereas the implementation of end-of pipe technologies such as additional filters may raise production costs thus reducing productivity and international competitiveness, the introduction of cleaner technologies may lead to the opposite result because of related material and energy savings leading to Hypothesis 1:

H 1 Only resource efficiency measures that leading to cost savings support performance whereas end-of-pipe measures might reduce performance

Furthermore, the development of greener products may create additional market opportunities. The famous Porter hypothesis (Porter, van der Linde 1995) stresses the point that environmental regulation helps to overcome eco-innovation barriers consisting in imperfect information, organizational problems and market failures (see Horbach 2015 for a more detailed discussion). The regulation-induced eco-innovations may thus lead to an increase in competitiveness and even first-mover advantages for the eco-innovators. Some authors make the distinction between a weak and a strong version of the Porter hypothesis (see Jaffe and Palmer, 1997, Lanoie et al., 2011 for an empirical analysis). The so-called weak version of the Porter hypothesis postulates that regulation induces eco-innovations without claiming that these innovations are also socially benign. The strong version goes a step further assuming that the regulation-induced innovations overcompensate for the cost of compliance thus leading to an increase in the competitiveness of the firm. The existence of these possible extra-returns and first-mover advantages (Gagliardi et al. 2016) show that investment in resource efficiency might be advantageous compared to other investment activities leading to Hypothesis 2 and 3:

H 2 A high amount of resource efficiency investment triggers the performance of a firm

H 3 The greenness of a firm is positively correlated to its performance

Specificities of SME´s

Following the definition of the Institut für Mittelstandsforschung (IfM) in Bonn SME´s are defined as firms employing less than 500 workers with an annual turnover that does not exceed 50 million euros (IfM 2016). On the one hand, small firms might be more flexible and open to new innovation fields but on the other hand, SME´s might be specifically affected by innovation barriers (Tiwari, Buse 2007, Belitz, Lejpras 2014, Marin et al. 2015, Ghisetti et al. 2015): High fixed innovation costs might reduce the availability of external financing because of high economic risks whereas big firms may finance a failure of an innovation project by the success of other projects. SME´s may be more affected by labor shortage because bigger firms are more attractive for applicants. For instance, the results of a survey in Hamburg show that "financing" and "finding suitable human resources" were the top innovation barriers for SME´s (Tiwari, Buse 2007). Furthermore, limited internal know-how and resources, missing possibilities to enter foreign markets because of the lack of an adequate logistic structure may reduce the ability to manage innovation processes. Additionally, bureaucratic hurdles such as long administrative procedures may be more problematic for SME´s because of their limited resources.

Therefore, the analysis for SME´s seems to be interesting because small firms might be especially affected by the costs of environmental measures as the introduction of resource efficiency measures are costly in the short run. For SME´s with limited financial possibilities these short run costs may constitute an important barrier to invest in cleaner technologies despite considerable cost saving effects in the long run (see also Ghisetti et al. 2015). Following Soltmann et al. (2015:460) “The development of green products and processes usually implies investing in technologies that lie beyond the firm’s traditional technological scope …” because the firm’s resource base has to be enlarged and adapted and/or business processes and working routines have to be changed, too.

On the other side, it might be possible that especially “young pioneers” confirm the validity of the Porter hypothesis. Many examples in the past show that young and small firms are often more likely developing totally new ideas and products whereas big and established firms are not able to change their innovation paths. For instance, at the end of the seventies, small firms (Intel and Microsoft) pushed the development of personal computers instead of firms such as IBM that were specialized in the production of mainframe computers. Therefore, first mover advantages are often based on the activities of small and medium-sized firms. The problem is that the small firms are less able to bear the risks of developing new products. A strict envi-

ronmental regulation in a country may create opportunities and demand security thus reducing the risks for SME´s.

On the other hand, big, older and experienced firms (Leoncini et al. 2016) are more likely to manage the higher complexity of eco-innovation and their higher need for technology experience. Therefore, the role of the size and the age of a firm for the relationship of eco-innovation and performance remains an empirical question. As our sample only contains SME´s and not big firms with a long experience and tradition the afore-mentioned argument might be more important but the SME´s might need external support to manage the complexity of eco-innovation thus leading to the hypotheses 4 and 5:

H 4 Young "pioneers" are more likely to realize a good performance

H 5 SME´s using external support show a better performance

Literature overview

In the following, the recent empirical literature on the economic effects of eco-innovation is shortly summarized[2].

One part of the studies concentrate on the effects of eco-innovation on productivity, further studies on the analysis of the relationship between eco-innovation and firm growth.

Rennings and Rammer (2011) use data from the German innovation survey of 2003. They detect similar success in terms of sales with new products and cost savings of environmental regulation driven innovations and other, non-environmentally related innovations. This result does not hold for all environmental innovation fields. Whereas regulations in favor of sustainable mobility, recycling, waste management or resource efficiency lead to higher sales, regulations in the field of water management are connected with a decrease of sales.

Ghisetti and Rennings (2014) use the eco-innovation question of the MIP 2009 and the wave of 2011 to measure the return on sales as outcome variable. They find positive profitability effects of innovations leading to a reduction in the use of energy and resources. On the other side, more end-of-pipe oriented innovations such as harmful materials and air, water, noise and soil pollutions show a negative influence on performance. In a study based on the same data basis, Rexhäuser and Rammer (2014) distinguish between regulation-induced and volun-

[2] See also Barbieri et al. (2016) for a more comprehensive analysis. Please that this short overview does not consider the employment effects of eco-innovation. For such an overview see e. g. Horbach and Rennings (2013).

tary environmental innovations. Regulation driven eco-innovations that improve firms´ resource productivity seem to have a stronger effect on profitability compared to voluntarily introduced eco-innovations. Mohnen and van Leeuwen (2013) and Rubashkina et al. (2015) confirm the weak but not the strong version of the Porter hypothesis. Marin et al. (2015) analyze the effects of the EU ETS on economic performance at the firm level. They use different indicators of performance such as value added, turnover, employment, investment, labour productivity, total factor productivity and markup. "Summing up, our estimates suggest that the EU ETS, despite its negative (but small) impacts on productivity and profitability, has stimulated the growth of firms" (Marin et al. 2015:15).

Franco and Marin (2015) use a panel of eight European countries for 13 manufacturing sectors over the years 2001-2007. The authors measure direct effects of environmental taxes on productivity but also indirect effects by induced innovation in upstream and downstream sectors. They find out that "… downstream regulation generates opportunities for innovation and may create markets for new and improved intermediate goods, upstream regulation acts as a constraint which negatively affects innovation and, even more strongly, productivity." (Franco, Marin 2015:29).

Hottenrott et al. (2016) show a complementarity effect of green technology adoption and organizational change. Only those green technologies that are accompanied by organizational changes are connected with a constant or higher productivity.

Based on panel data of environmental R&D activities, Reif and Rexhäuser (2015) show the positive role of corporate social responsibility (CSR) for a better financial performance. Firms signalling their environmental engagement through CSR seem to improve their financial performance. In a recent analysis of Soltmann et al. (2015) new industry-level panel data for 12 OECD and 30 years countries is exploited. "The results show that green inventions are U-shape related to performance. However, the turning point is quite high and hence only relevant for a few industries. This indicates that - given the current level of green promotion - market incentives alone are not sufficient to allow the green invention activities of industries to rise considerably." (Soltmann 2015:457). Based on a patent analysis, Lotti and Marin (2015) find out that eco-innovations show a lower return compared to other innovations. This seems to be especially true for polluting firms facing high compliance costs.

A recent paper (Leoncini et al. 2016) on the effects of eco-innovation on firm growth applying quantile regressions show higher growth effects of green technologies compared to other technologies for moderately growing firms but not for rapidly growing firms. Older and experienced firms profit more from the introduction of green technologies due to the complexity of

managing eco-innovation. Based on a patent analysis, Colombelli et al. (2015) find out that eco-innovation activities are especially benign for already fast growing firms.

The following empirical analysis tries to answer the question which different resource efficiency measures are correlated to a better performance and profitability. Furthermore, the specific situation and constraints of SME´s are considered.

3. Empirical Analysis

3.1 Data basis and descriptive statistics

The analysis uses data from the EUROBAROMETER 2013 on resource efficiency and green markets (European Commission 2014). The data basis includes the 28 Member States of the European Union and in Albania, Israel, Iceland, Liechtenstein, Montenegro, Former Yugoslav republic of Macedonia, Norway, Republic of Serbia, Turkey and the United States and focuses on small and medium sized enterprises (up to 249 employees).

Table 1: Distribution of the sample by firm size and sectors

Number of employees	**Number of firms**	**in %**
1 to 9 employees	6,166	46.0
10 to 49 employees	4,681	34.7
50 to 249 employees	2,660	19.7
Total	13,507	100.0
Sectors by NACE		
B - Mining and quarrying	84	0.6
C Manufacturing	2,890	21.4
D - Electricity, gas, steam and air conditioning	105	0.8
E - Water supply, sewerage, waste management	262	1.9
F Construction	2,216	16.4
G - Wholesale and retail trade, repair	4,264	31.6
H Transportation and storage	737	5.5
I - Accommodation and food service activities	727	5.4
J - Information and communication	464	3.4
K - Financial and insurance activities	231	1.7
L - Real estate activities	276	2.0
M - Professional, scientific and technical services	1,253	9.3
Total	13,509	100.0

Source: European Commission (2014), own calculations.

The survey covers 13,509 observations (11,207 from the EU) in the manufacturing (NACE category C), services (NACE categories G/H/I/J/K/L/M/N) and industry sector (NACE cate-

gories D/E/F). The respondents of the questionnaire had to be a general manager, a financial director or a significant owner (for a more detailed description of the database see European Commission 2014). The sample is dominated by very small firms from 1 to 9 employees (see Table 1), the most important sectors are "wholesale, retail trade, repair" (32%), manufacturing (21%) and construction (16%). More than one third of the firms offer green products or services, for nearly 20% the turnover share of these products is higher than 75% (see Table 2). About 54 percent of the questioned firms stated that their investments in resource efficiency led to a reduction of production costs (Table 2). For most of the firms (85.5%), the turnover share of these investments did not exceed 5%.

Table 2: Resource efficiency measures and green products

Does your company offer green products or services?	**Number of firms**	**in %**
Yes	3,865	30.6
No, but we are planning to do so in the future	1,014	8.0
No, and we are not planning to do so	7,751	61.4
Total	12,630	100.0
How much do these green products or services represent in your annual turnover?		
1- 5%	1,279	37.8
6-10%	506	14.9
11-30%	486	14.4
31-50%	269	7.9
51-75%	191	5.6
More than 75%	655	19.13
Total	3,386	100.0
Investment to improve resource efficiency (in % of annual turnover)		
Less than 1%	4,903	46.6
1-5%	4,086	38.9
6-10%	977	9.3
11-30%	373	3.5
More than 30%	174	1.7
Total	10,513	100.0
What impact have the undertaken resource efficiency actions had on the production costs?		
It significantly decreased production costs	720	6.4
It slightly decreased production costs	5,291	47.1
It slightly increased production costs	1,950	17.4
It significantly increased production costs	558	5.0
It had no impact	2,711	24.1
Total	11,230	100.0

Source: European Commission (2014), own calculations.

3.2 Econometric model and estimation results

The performance effects of environmental and resource efficiency activities are measured by two different indicators. On the one side, the turnover development of the preceding two years denotes the actual performance development. As this indicator does not capture the profitability of the firm, the self-perceived resource investment profitability is used. Due to data restrictions, these two outcome variables are only binary. Firms showing a successful performance in terms of turnover development (*turnoverdev*) might be also more likely to report high self-perceived resource investment profitability (*selfpercprof*). Consequently, the two outcomes may be correlated leading to inconsistent estimates of simple probit models so that a bivariate probit model has to be estimated. This model reads as follows (Greene 2008):

$$(1)\, turnoverdev_i = x_i'\alpha + \varepsilon_i$$
$$(2)\, selfpercprof_i = y_i'\beta + \mu_i$$

If the cov (ε_i, μ_i) = ρ is zero, "… then the log likelihood for the bivariate probit models is equal to the sum of the log likelihoods of the two univariate probit models. A likelihood-ratio test may therefore be performed by comparing the likelihood of the full bivariate model with the sum of the log likelihoods for the univariate probit models." (STATACorp 2015: 183).

Description of variables (for a detailed description see the Appendix)

The variable *sharegreenprod* gets the value one if the share of green products and services on total turnover is higher than 10%. *Costenv* denotes the situation if the questioned firm had difficulties to introduce resource efficiency measures because of high costs of these measures. The lack of demand for ecological products and services is denoted by the dummy variable *lackdemand*. If additional profits and an expected increase in competitiveness are main motivations to realize resource efficiency measures the variable *profits* gets the value one. *Highgreenjob* denotes a high share of employees related to environmental issues (e. g. control of environmental regulations, production or marketing of green products etc.). *Investresource* gets the value one if the firms spent more than five percent of yearly turnover in measures improving resource efficiency. *EMS* captures the implementation of an environmental management system. The variables *consumer*, *firm* and *public* describe the different customers of a firm´s products and services.

Table 3: Performance effects of resource efficiency measures – all sectors

Correlates	Turnover development	Self-perceived profitability
Resource efficiency measures		
EMS	0.01 (0.75)	0.02 (2.77)**
Investresource	0.05 (3.93)**	0.06 (7.16)**
Measenergy	0.01 (0.87)	0.00 (0.05)
Measmaterial	-0.00 (-0.14)	-0.01 (-1.16)
Measrecyc	0.00 (0.39)	0.01 (1.87)+
Measrenewable	0.04 (2.70)**	0.03 (3.33)**
Measscrap	0.02 (1.44)	0.01 (0.82)
Measwater	-0.02 (-1.76)+	0.01 (1.61)
Measwaste	-0.00 (-0.20)	-0.01 (-1.38)
Greenness of the firm		
Greenness	0.03 (2.31)*	0.05 (6.08)**
Highgreenjob	0.05 (3.56)**	-0.00 (-0.09)
Sharegreenprod	0.01 (0.62)	0.01 (1.69)+
Control variables		
Consumer	-0.01 (-1.48)	-0.00 (-0.15)
Extern	0.04 (3.91)**	0.01 (1.04)
Firm	0.06 (6.30)**	-0.01 (-0.70)
Costenv	-0.03 (-2.70)**	-0.03 (-4.74)**
Profit	0.03 (2.18)*	-0.00 (-0.47)
Knowhow	0.01 (1.31)	0.02 (4.35)**
Lackdemand	0.00 (0.07)	-0.00 (-0.63)
Oneperson	-0.13 (-8.23)**	0.01 (0.92)
Ownfinance	0.01 (1.55)	0.04 (6.28)**
Public	0.02 (1.89)+	-0.00 (-0.37)
Size	0.11 (11.0)**	0.00 (0.31)
Young	0.16 (18.4)**	0.01 (1.64)+

Bivariate probit estimation reporting marginal effects. Number of observations: 13,376. Wald $\chi2$ (144) = 2,156. Z-statistics are given in parentheses; +, * and ** denote significance at the 10%, 5% and 1% level, respectively. Rho = 0.12. Likelihood-ratio test of rho=0: $\chi2$ (1) = 36.0. Prob > $\chi2$ = 0.00. Sector/country dummies and constants are included but not reported.

Greenness characterizes firms that declare environmental questions as core priorities. From their self-perceived perspective, these firms try to go beyond the requirements of environmental regulations. If measures to improve resource efficiency are mainly based on own financial resources and own technical know-how, the variables *ownfinance* and *knowhow* get the value one. On the other side, *extern* denotes the importance of external support for these measures. The variables *measwater*, *measenergy*, *measrenewable*, *measmaterial*, *measwaste*, *measscrap*,

measrecycling describe measures of the firms to improve resource efficiency in different environmental technology fields. *Size* gets the value one if the number of employees exceeds 50. A firm is defined as *young* if it has been founded less than ten years ago. *Oneperson* denotes firms having only one employee. Sector and country dummies are also included.

For our performance indicator, the turnover development of the past two years, the results of the bivariate probit model show that a high amount in investment in resource efficiency measures triggers the performance of the firm supporting H 2.[3] The self-perceived profitability is also positively correlated to the share of investments in resource efficiency but this may also be due to the fact that high amounts of money spent in resource efficiency measures are motivated by expected positive returns. On the other side, firms characterized by low resource investment shares mainly aim at fulfilling regulation requirements. The greenness of a firm measured by a high priority of environmental concerns (*greenness*) and a high share of green jobs (*highgreenjobs*) is significantly and positively correlated to the turnover development (H 3).

Not all measures in improving the resource efficiency are connected with a positive performance (H 1): An increased use of renewables leads to a higher performance whereas measures to reduce water consumption are even negatively correlated to the turnover development corroborating the results of Rennings and Rammer (2011). This result is confirmed for the self-perceived profitability of resource efficiency. Concerning this indicator, recycling related measures (*measrecyc*) also show a weakly significant positive influence.

The introduction of Environmental Management Systems (*EMS*) seems not to be relevant for the performance indicator but for the self-perceived profitability where *EMS* is highly significant. EMS help to improve the profitability of resource efficiency related investments by identifying cost or material saving possibilities within a firm. Not surprisingly, firms showing increased problems to bear the costs of environmental and resource efficiency measures are also low performers documented by the significantly negative influence of *costenv*. This result also holds for the self-perceived resource efficiency indicator.

[3] It is important to notice that the results of the econometric analysis have to be interpreted as correlations rather than causal effects because of the cross section character of the data. Furthermore, the formulation of some questions does not allow the identification of an exact time structure.

Table 4: Performance effects of resource efficiency measures by different sectors

Correlates	Turnover development		Self-perceived profitability	
	Production sectors (NACE B-F)	Service sectors (NACE G-M)	Production sectors (NACE B-F)	Service sectors (NACE G-M)
Resource efficiency measures				
EMS	0.01 (0.76)	0.01 (0.72)	-0.00 (-0.05)	0.03 (3.73)**
Investresource	0.06 (3.58)**	0.03 (1.99)**	0.06 (5.38)**	0.05 (4.93)**
Measenergy	0.02 (0.80)	0.01 (0.68)	0.00 (0.27)	-0.00 (-0.01)
Measmaterial	-0.01 (-0.32)	0.00 (0.28)	-0.01 (-0.87)	-0.01 (-0.79)
Measrecyc	0.01 (0.48)	-0.00 (-0.09)	0.01 (0.58)	0.02 (2.04)*
Measrenewable	0.04 (1.60)	0.04 (1.88)+	0.03 (2.40)*	0.03 (2.40)*
Measscrap	0.03 (1.74)+	0.01 (0.63)	-0.00 (-0.09)	0.01 (0.96)
Measwater	-0.03 (-1.76)	-0.02 (-1.11)	0.04 (2.83)**	-0.00 (-0.33)
Measwaste	-0.03 (-1.33)	0.01 (0.68)	-0.02 (-1.29)	-0.01 (-0.72)
Greenness of the firm				
Greenness	0.01 (0.58)	0.04 (2.58)**	0.03 (2.65)**	0.06 (5.74)**
Highgreenjob	0.05 (2.37)*	0.05 (2.62)**	0.01 (0.53)	-0.01 (-0.63)
Sharegreenprod	0.02 (1.10)	-0.01 (-0.42)	0.02 (2.05)*	0.00 (0.34)
Control variables				
Consumer	0.02 (1.24)	-0.04 (-3.08)**	-0.00 (-0.44)	0.00 (0.29)
Extern	0.04 (2.39)*	0.04 (2.97)**	0.00 (0.20)	0.01 (1.08)
Firm	0.06 (3.90)**	0.06 (4.63)**	-0.00 (-0.29)	-0.00 (-0.58)
Costenv	-0.04 (-2.73)**	-0.01 (-1.04)	-0.03 (-3.23)**	-0.03 (-3.41)**
Profit	-0.00 (-0.06)	0.05 (2.83)**	-0.01 (-0.53)	-0.00 (-0.11)
Knowhow	0.02 (1.79)+	0.01 (0.42)	0.02 (1.88)+	0.03 (3.74)**
Lackdemand	0.01 (0.80)	-0.01 (-0.51)	-0.01 (-1.18)	0.00 (0.30)
Oneperson	-0.13 (-4.69)**	-0.13 (-6.74)**	0.01 (0.55)	0.01 (0.65)
Ownfinance	0.04 (2.74)**	-0.00 (-0.17)	0.02 (2.48)**	0.04 (5.87)**
Public	0.01 (0.81)	0.02 (1.83)+	0.01 (0.54)	-0.01 (-0.85)
Size	0.11 (7.10)**	0.12 (8.64)**	0.03 (2.76)**	-0.02 (2.76)+
Young	0.18 (12.67)**	0.16 (13.61)**	0.01 (0.75)	0.01 (1.51)

Bivariate probit estimation reporting marginal effects. Z-statistics are given in parentheses; +, * and ** denote significance at the 10%, 5% and 1% level, respectively. Sector/country dummies and constants are included but not reported.

Production sectors:
Number of observations: 5,512. Wald $\chi2$ (130) = 925. Rho = 0.17. Likelihood-ratio test of rho=0: $\chi2$ (1) = 30.9. Prob > $\chi2$ = 0.00.

Service sectors
Number of observations: 7,864. Wald $\chi2$ (134) = 1,326. Rho = 0.09. Likelihood-ratio test of rho=0: $\chi2$ (1) = 11.2. Prob > $\chi2$ = 0.00.

As concerns further control variables, young firms show a better turnover and a higher self-perceived profitability of resource related measures (H 4). The effect that young firms are more dynamic in developing new ideas and turning them over in innovations seems dominating the fact that old, big and experienced firms are better capable to realize complex eco-innovations. This may be due to the sample exclusively containing SME´s. The size of the firm is positively correlated to turnover development, very small firms (*oneperson*) show a significantly weak performance. External support significantly helps SME´s to improve performance supporting H 5. Interestingly, this variable is not significant in relation to the self-perceived efficiency indicator. The questioned firms seem to be convinced that the own technical knowhow and the own financial resources are crucial for the success of resource related measures.

In a further step, two separate bi-probit models for production-oriented sectors and the service sector were estimated (Table 4). The results show that the cost barrier (*costenv*) is not relevant for the performance in the service sector but only for the production sector. That is not surprising because in the production sector the introduction of resource efficiency related measures often requires high investments in physical capital whereas in the service sector mere organizational and logistic changes are sufficient in many cases. In the production sector where the costs of environmental measures seem playing a more important role, firms relying on own financial resources (*ownfinance*) show a better performance. On the other side, resource efficiency measures creating additional market opportunities (*profit*) are more important for services whereas this variable is not significant for the production sector. A high priority for environmental concerns (*greenness*) is positively related to the performance of firms belonging to the service sector but not for manufacturing firms. For the self-perceived profitability, *EMS* as a soft instrument is only significant for services.

4. Summary and conclusions

The paper analyzes the performance effects of different resource efficiency measures. Two indicators to measure performance and the profitability of environmental measures are used. On the one side, the turnover development of the preceding two years denoting the actual performance development, on the other side the self-perceived resource investment profitability is used. Due to data restrictions, these two outcome variables are only binary. As the two out-

comes may be correlated leading to inconsistent estimates of simple probit models, bivariate probit models have been estimated.

The results of the bivariate probit models show that a high amount in investment in resource efficiency measures triggers the overall performance of the firm. A high amount of self-perceived greenness of the firm and of a high share of green employment is positively correlated to performance. In fact, not all measures in improving resource efficiency are connected with a positive performance: An increased use of renewables leads to a higher performance whereas measures to reduce water consumption are negatively correlated to the turnover development. Young firms show a better turnover development, the results also show that external financing is significantly important for a good performance. Firms characterized by increased problems to bear the costs of environmental and resource efficiency measures are also low performers. The firm size is positively correlated to performance, a significantly negative performance of one person firms could be observed.

The results for the indicator "perceived resource investment profitability" widely confirms the results of the turnover development. Measures introducing renewables are again favorable to improve profitability, furthermore recycling is significantly positively correlated to investment profitability. The significantly positive effect of Environmental Management Systems (EMS) on perceived resource investment profitability is plausible because these systems provide information and thus help to reveal energy or material saving potentials in a firm.

All in all, the results show that especially investment in renewable energy technologies is correlated to positive performance effects but the realization of such measures in SME´s is highly dependent on external financing sources.

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Appendix: Description of the variables

Variables	Description	Mean	St. Dev.
Dependent variables			
Turnoverdev	1 Increasing turnover during the last two years, 0 Constant or decreasing turnover	0.35	0.48
Selfpercprof	1 Highly satisfied with measures to improve resource efficiency, 0 Other	0.12	0.32
Resource efficiency measures	Which of the following measures are implemented in your firm (1 yes, 0 no)?		
EMS	Environmental Management System	0.22	0.41
Measenergy	Energy reduction	0.34	0.47
Measmaterial	Material reduction	0.30	0.46
Measrecyc	Recycling	0.24	0.42
Measrenewable	Predominant use of renewable energy	0.08	0.27
Measscrap	Sale of scrap to other firms	0.18	0.38
Measwater	Reduction of water use	0.25	0.43
Measwaste	Reduction of waste	0.31	0.46
Investresource	1 Resource efficiency investment share on turnover greater than 5%, 0 Other	0.11	0.32
Greenness of the firm			
Greenness	1 Environment is a core priority of the firm, firm goes beyond requirements of regulations, 0 Other	0.12	0.33
Highgreenjob	1 High share of green jobs, 0 Other	0.09	0.28
Sharegreenprod	Share of green products on turnover greater that 10%, 0 Other	0.12	0.32
Control variables	1 yes, 0 no		
Consumer	Consumers as end-users	0.63	0.48
Firm	Sales to other firms	0.69	0.46
Public	Sales to public institutions	0.30	0.46
Costenv	Cost of resource efficiency measures as barrier	0.22	0.42
Extern	External support to realize resource efficiency	0.19	0.39
Profit	Improvement of the competition situation as motivation for resource efficiency measures	0.13	0.33
Knowhow	Internal know-how to realize resource efficiency	0.49	0.50
Lackdemand	Lack of demand for eco-products	0.16	0.36
Oneperson	One-person-company	0.08	0.27
Ownfinance	Self-financed resource efficiency measures	0.62	0.48
Size	1 Between 50 and 250 employees, 0 Other	0.20	0.40
Young	Age of the firm less than 10 years, 0 Other	0.25	0.43

Sector dummies	1 yes, 0 other sector		
Sec1	Mining and quarrying	0.01	0.08
Sec2	Manufacturing	0.21	0.41
Sec3	Electricity, gas , steam and air condition	0.01	0.09
Sec4	Water supply, sewerage, waste management	0.02	0.14
Sec5	Construction	0.16	0.37
Sec6	Wholesale and retail trade, repair	0.32	0.46
Sec7	Transportation and storage	0.05	0.23
Sec8	Accommodation and food service activities	0.05	0.23
Sec9	Information and communication	0.03	0.18
Sec10	Financial and insurance activities	0.02	0.13
Sec11	Real estate activities	0.02	0.14
Sec12	Professional, scientific and technical activities	0.09	0.29
Country dummies	1 yes, 0 other country		
AL	Albania	0.01	0.09
AT	Austria	0.03	0.17
BE	Belgium	0.03	0.17
BG	Bulgaria	0.03	0.17
CY	Cyprus	0.01	0.12
CZ	Czech Republic	0.03	0.17
DE	Germany	0.04	0.19
DK	Denmark	0.03	0.17
EE	Estonia	0.03	0.17
ES	Spain	0.04	0.19
FI	Finnland	0.03	0.17
FR	France	0.04	0.19
GB	Great Britain	0.04	0.19
GR	Greece	0.03	0.17
HR	Croatia	0.03	0.17
HU	Hungary	0.03	0.17
IE	Ireland	0.03	0.17
IL	Israel	0.02	0.15
IS	Island	0.01	0.12
IT	Italy	0.04	0.19
LI	Liechtenstein	0.01	0.09
LT	Lithuania	0.03	0.17
LU	Luxembourg	0.01	0.12
LV	Latvia	0.03	0.17
ME	Montenegro	0.01	0.09
MK	Macedonia	0.01	0.12
MT	Malta	0.01	0.12
NL	Netherlands	0.03	0.17
NO	Norway	0.02	0.15
PL	Poland	0.04	0.19
PT	Portugal	0.03	0.17
RO	Romania	0.03	0.17
RS	Serbia	0.01	0.12
SE	Sweden	0.03	0.17

SI	Slovenia	0.03	0.17
SK	Slovakia	0.03	0.17
TR	Turkey	0.02	0.15
US	United States	0.04	0.19