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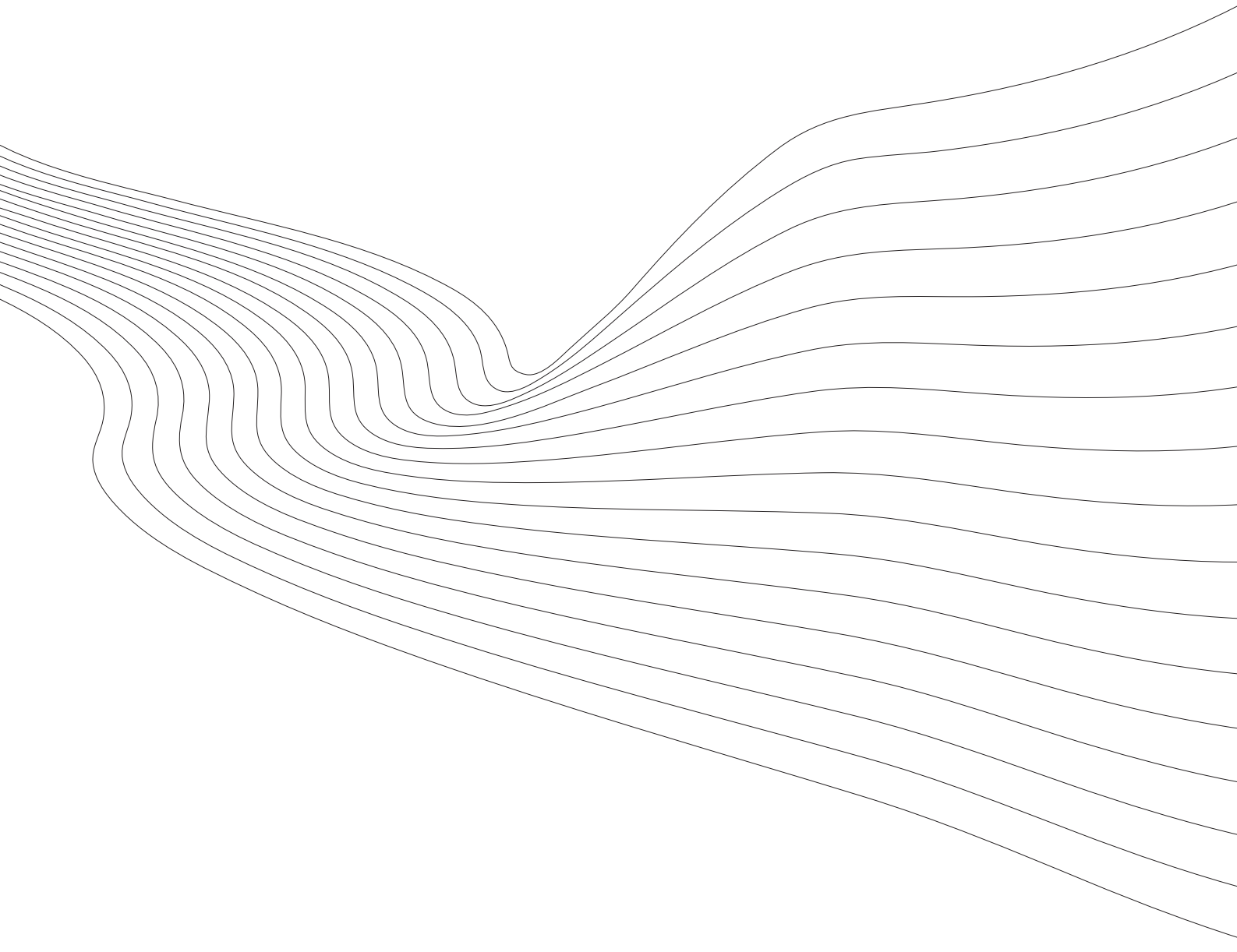

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Factors Determining the Adoption of Energy-saving Technologies in Swiss Firms – An Analysis based on Micro Data*

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Abstract

This study investigates the factors that determine the inter-firm and intra-firm adoption rates of energy-saving technologies. These factors can be on theoretical terms firm-specific rank effects, inducement effects, adoption barriers as well as order, stock and epidemic effects that are related to different kinds of external effects. Data for 2324 Swiss firms for the year 2008 are used that contain information about four categories of energy-saving technology applications (electromechanical and electronic applications; applications in motor vehicle and traffic engineering; in building construction; and in power-generating processes) that are studied separately. The results show that there are significant differences with respect to rank effects and adoption barriers between inter-and intra-firm diffusion. In practically all cases positive epidemic and/or network effects outweigh potential negative stock and order effects. Inducement effects, particularly those traced back to intrinsic motivations for environment-friendly technologies, show clearly positive effects on the adoption rates.

Key words: energy-saving technologies; technology adoption

JEL classification: O31; O33

1. Introduction

Energy efficiency and energy policy have been high on the agenda of economic research in recent years. Moving towards an economy that uses energy in a more sustainable manner will remain a major challenge to enterprises and policymakers for the near and future and beyond, despite the obvious difficulties encountered by international politics to agree on binding reduction targets for greenhouse gas emissions. It is clear that the implementation of technologies and practices that increase firms' and households' energy efficiency – that is to say, which enable to produce or provide given amounts of goods or services using less energy inputs – are of crucial importance to meet this challenge. Only then can we expect to maintain the high level of standard of living industrialised countries enjoy today and developing countries are striving to catch up with.

This paper attempts to shed light on the driving forces of the diffusion of ready-to-use energy efficient technologies among firms. As remarked by Battisti (2008), much of the existing literature on new technology (and, specifically, green technology) solely focuses on the R&D and innovation stage, rather than the actual diffusion of such technology among final users. This seems odd, given the observed fact that "the diffusion of a technology is a very slow and heterogeneous process and this is true (…) for green technologies that are notoriously slower than traditional technologies at diffusing within and across firms" (Battisti 2008, p. S29). In the same survey, the author raises concern that empirical research so far has mostly neglected the patterns of intra-firm diffusion of new technologies, largely due to data restrictions.[1]

Moreover, several academics (Popp et al. 2009 provide a survey) and practitioners (most prominently, McKinsey & Company with their "Greenhouse gas abatement cost curves" initiative[2]) have pointed to the fact that adoption of energy-saving technologies among firms takes place slowly or not at all even in cases where the potential private gains (through lower energy input requirements or related cost savings) outweigh the associated costs. In a more long-term and macro-oriented setting, some narrative and empirical findings likewise suggest that increased involvement in green technology (or, specifically, energy efficiency) may have noticeable welfare-enhancing effects rather than causing net costs or decreasing a country's competitiveness (see, for instance, Cadot et al. 2009 for a cross-country, cross-industry survey on the topic).

However, we deem it important to better understand the patterns of diffusion of energy efficient technologies; given that potential market failures (the existence of which many of these studies suggest) might encourage stronger policy measures for technology adoption in the future.

[1] However, the fact that The *Journal of Cleaner Production* dedicated a special issue to the diffusion of cleaner technologies (Volume 16, Issue 1, Supplement 1, pp. S1-S184) shows that there is an increasing interest for this subject.

[2] http://www.mckinsey.com/clientservice/ccsi/costcurves.asp.

A remarkable body of literature related to the adoption of cleaner technologies has been accumulated over the past fifteen years, yet many open questions remain. In a broad survey of studies dealing with the subject, Montalvo (2008) has identified several difficulties such analyses are confronted with: the multitude of factors potentially affecting the adoption decision at the firm level, and the limited availability of longitudinal data which severely restricts the possibility to investigate the dynamics of diffusion processes. In addition, findings of industry-specific surveys often cannot be generalised to the whole economy, and for some time research of technology diffusion has been divided in different streams that are difficult to reconcile with each other.

A further branch of literature focuses on the slowness of the dissemination of technologies that enhance energy efficiency and analyzes the reasons for the "energy-efficiency gap" that presumably exists between actual and optimal level of energy efficiency (see, e.g., Jaffe and Stavins 1994 and DeCanio 1993). As a consequence empirical research in some papers concentrates on the potential barriers of the diffusion of energy-saving technologies, thus neglecting other important factors that may impact the adoption rate (see, e.g., De Groot et al. 2001; DeCanio 1998; and Reddy and Painuly 2004).

We attempt to relieve some of these difficulties by drawing on a new dataset of Swiss firms that has been collected by means of a survey specifically designed to this task, covering a broad range of particular energy efficient technologies as well as stemming from a wide spectrum of enterprises covering the industrial (including energy and water) as well as the construction and service sectors. Despite the cross-sectional nature of our data, which evidently limits the possibilities to conduct truly dynamic analysis, we are capable of implementing an econometric approach that allows some inference about market and non-market intermediated externalities as well as differentiating between the inter-firm and intra-firm aspects of technology diffusion.

The paper is structured as follows. In section 2 the theoretical background and the model specification are presented. In section 3 the data used in this study are described. Section 4 contains descriptive information about the inter-firm and intra-firm adoption rates of the energy-saving technology applications analyzed in this study. In section 5 the empirical results are presented and discussed. Section 6 contains a summary and some conclusions.

2. Framework of analysis

2.1 Theoretical background

In a recent paper Battisti et al. (2009) presented an integrated model of diffusion that integrates the analysis of inter-firm and intra-firm diffusion, mostly modelled separately, in an

encompassing framework, in which inter- and intra-diffusion are treated simultaneously.[3] This study is an extension of Karshenas and Stoneman (1993) and subsequent work of Battisti (2000). This model builds the main base for our conceptual framework. According to equation (3a) in Battisti et al. (2009, p. 136) $A_i^*(t)$, the firm's desired or optimal level use of new technology in time t, i.e. the desired extent of both inter- and intra-firm diffusion, is a function of the following factors:

(1) Characteristics of a firm i (a vector $F_i(t)$ of variables that have to be specified) and its environment (a vector $F_j(t)$ of variables for industry j that have also to be specified) reflecting *rank effects*. The cause for rank effects is firms' heterogeneity leading to differing returns to adoption and thus differing reservation prices (see, e.g., Davies 1979 and Ireland and Stoneman 1986). In this case the inter-firm concept of rank effects is extended to intra-firm technology use. These effects are expected in general to be positive.

(2) The extent of industry usage of new technology $SO_j(t)$ capturing inter-firm *stock* and *order effects* (i.e. market-mediated externalities[4]). Stock effects are based on the assumption that the returns to technology adoption decrease with the number of firms utilizing this technology (see, e.g., Reinganum 1981). Order effects depend also on the number of adopters but specifically at the time of adoption. For a certain level of adoption costs at a certain point in time, it is profitable to be the first adopter; as costs decrease with time, adoption becomes profitable also for a second firm, then a third, and so on (see, e.g., Fudenberg and Tirole 1985). In general, these effects are expected to be negative, unless positive *network effects* are strong enough to outweigh them.

(3) Positive *epidemic* effects (i.e. learning and network non-market intermediated externalities) reflecting either the firm's own experience with the new technology $E_i(t)$, often proxied by the time since the firm's first adoption, or the experience gained from observing other firms $E_j(t)$ (often proxied by the extent of technology diffusion in time t).

(4) The expected adoption cost of a unit technology $P_i(t)$ constituting of two parts, one common to all firms, e.g., the price of machines, and a second one reflecting firm-specific adjustment and installation costs.

In accordance to the particular conditions of the introduction of energy-saving technologies in Switzerland (as in many other countries) also elements of the literature on *induced innovation and technology diffusion* (see, e.g., Binswanger 1974) are taken into consideration. The diffusion of energy-saving technologies can be positively influenced (a) through increases of energy prices and/or taxes (see, e.g., Linn 2008 and Jacobs et al. 2009) and (b) through public

[3] For recent reviews of the literature on the theory of technology diffusion in general see Sarkar (1998) and Geroski (2000).

[4] External effects mediated by the market are so-called "pecuniary externalities" that arise from direct pecuniary benefits to users; external effects that are not mediated by the market are so-called "technological externalities" and encompass indirect benefits through learning effects (see Battisti et al. 2009, p. 141 and further literature cited there).

regulation and/or public incentives to use energy-saving technologies (see, e.g., Popp et al 2009). We consider a vector $IA_i(t)$ of variables that capture the influence of such factors (*inducement effects*). These variables are reflecting both firm-specific (e.g., due to high share of energy costs; due to value-oriented "intrinsic" effects) and industry-specific or economy-wide effects (e.g., due to high energy prices).

A formal expression of the relation of between the optimal level of use of new technology and the factors presented above is as follows:

$$A_i^*(t) = G[F_i(t), F_j(t), SO_j(t), E_i, E_j, P_i(t), IA(t)] \qquad (1)$$

As expressed in the above equation, the adoption of new technology as well as the more intensive use of it build a dynamic process. However, since we dispose of data only for a single cross-section, is not possible to specify a dynamic model. Instead, we apply a static version of the model to investigate the determinants of the diffusion of energy-saving technologies in the Swiss business sector in the year 2008. As a consequence, the variable $E_i(t)$ reflecting the firms' individual experience of the new technology cannot be measured in single cross-section and has to be ignored.[5] The finally operative expression of equation (1) after dropping the time subscripts is as follows:

$$A_i^* = G[F_i, F_j, SO_j, E_j, P_i, IA] \qquad (1a)$$

2.2 Model specification

We specified an empirical model that contains the same determinants for both inter- and intra-firm diffusion. Table 1a describes the adoption variables used in this study. Table 1b gives an overview of the variables used as determinants of adoption.

We used the following variables to measure *firm-specific rank effects* F_i:

Factor endowment. A firm's factor endowment, especially its endowment with human capital and know-how, is an important factor determining the firm's ability to adequately utilize new technologies. Capital intensity is measured by gross investment per employee (LN_INVEST/L), human capital intensity is measured by the share of employees with tertiary-level education (HQUAL), know-how intensity is measured by the ability to generate new knowledge as reflected in the existence of permanent R&D activities (R&D). We expect positive effects for all three variables.

Firm size. Here measured by the number of employees in full-time equivalents (LN_EMPL) firm size may capture firm-specific characteristics relevant for the technology adoption that are not specified in this model, such as management abilities, scale economies etc. This variable has been widely used as a determinant of technology diffusion in earlier studies; most

[5] However, it would be possible to control for $E_i(t)$ for those firms in the sample that reported the adoption of single technology applications in both periods, *before* and *after* 2004.

of these studies have found, at least for the case of inter-firm diffusion, a positive effect of firm size on diffusion (see, e.g., Karshenas and Stoneman 1995 for a survey of this literature). There is a further line of argumentation stating that due, e.g., to managerial diseconomies of scale larger firms, once they have adopted a new technology, tend to use it less intensively than smaller ones; in this case a negative effect of firm size on intra-firm technology adoption is expected (see, e.g., Fuentelsaz et al. 2003).

Export activities. Here measured by a dummy variable (export activities yes/no; EXPORT) may indicate an above-average propensity to adopt new technology in order to keep high its international competitiveness. A positive effect on diffusion is expected.

Foreign-ownership. Here measured by a dummy variable (foreign-owned firm yes/no; FOREIGN) indicates whether a firm is controlled by a foreign parent company. We expect in general a higher than average propensity of foreign-owned firms to adopt new technologies. However, depending on the conditions in home country foreign-owned firms may react differently as domestic firms to public regulation and/or incentives with respect to energy-saving in the host country. As a consequence, the sign of this variable is not a priori clear.

To measure *rank effects* as to the firm's *market environment* F_j we considered the following variables:

Demand prospects: Positive demand expectations (DEMAND) as perceived by the firms themselves may enhance the propensity to adopt new technologies because firms expect to distribute acquisition costs on a larger volume of products.

Competitive pressures: A well-known line of argument argues that it is the elasticity of demand faced by a firm in its specific market that induces innovative or imitative activity (see Kamien and Schwartz 1970 for the original argument). In those markets where competition pressure is greater, demand elasticity can be expected to be higher because of the existence of close substitutes, thus driving firms to innovative activity or rapid new technology adoption (see, e.g., Majumdar and Venkataaman 1993). In accordance to this line of reasoning, we proxied competitive pressures through the intensity of price (IPC) and non-price competition (INPC) on the product market (as perceived by the firms themselves) and expect a positive relationship to the propensity to adopt new technology.

In order to control for *epidemic effects* E_j we use two variables, one measure for *inter-firm* effects (share of firms having adopted new technology in the industry sub-sector the firm is affiliated (INTER_...), and a second one for *intra-firm* effects (mean of the firms' adopted technology applications in the industry sub-sector the firm is affiliated (INTRA_...) (see table 1b for more details about the variable construction).[6]

[6] It could be argued that such a variable is possibly only weakly exogenous or even endogenous because it is contemporaneous to the dependent variable. Unfortunately data limitations do not allow the construction of a lagged variable.

In a cross-section analysis, inter-firm epidemic effects E_j cannot be distinguished from *inter-firm order* and *stock effects* SO_i. Therefore, the estimated coefficients of these two variables measure the net effects, which may be positive (dominance of positive non-market intermediated epidemic effects and market intermediated network effects) or negative (dominance of the stock and order effects) or insignificant (the two opposite effects are equally strong), although it is not possible to say to which type of positive network effects the net positive effect is traced back.

To measure (indirectly) firm-specific *adoption costs* P_i we used a group of variables indicating various *barriers* to the adoption of energy-saving technologies that would postpone or even hinder completely the adoption of new technology because of different types of costs. We identified four groups of such barriers based on principal component factor analysis of 14 single obstacles of adoption, the importance of which has been assessed by firms on a five-point Likert scale (see table 1b and table A.4 in the appendix for more details): (a) lack of compatibility with current product programme or current production technology (high adjustment costs due to high sunk costs) (COMPAT); (b) too high investment expenditures, too low liquidity (high financing costs) (FIN); (c) information and knowledge barriers (information costs) (INFO); and (d) organizational and managerial barriers (ORGAN). We expect such barriers to be negatively correlated with adoption.

In order to measure *inducement factors* IA_i, we add the following variables to the model: (a) the sales share of energy costs as indicator of high reactivity to energy prices and/or taxes; (b) a variable indicating the a firm's willingness to take environmental criteria into consideration for procurement of intermediate inputs and reflecting its "intrinsic" motivation; and (c) a group of variables indicating various *motives* that would induce the adoption of energy-saving technologies. We identified four groups of such motives based on principal component factor analysis of 11 single motives for adoption, the relevance of which has been assessed by firms on a five-point Likert scale (see table 1b and table A.5 in the appendix for more details): (i) (expected) increases of energy prices and/or taxes that would enhance the propensity of the adoption of energy-saving technologies; (ii) (expected) public incentives for energy efficiency and / or CO_2 reduction (PUBLIC_ INCENT); (iii) (expected) public regulations and/or agreements between firms and government agencies with respect to energy efficiency (PUBLIC_REGUL); and (iv) other motives such as the (expected) increase of demand for environment-friendly products, expected energy bottlenecks or the "intrinsic" motivation for environment-friendly behaviour. We expect positive effects for the four motive variables.[7]

[7] These variables are available for adopting firms only.

3. Data

The data used in this study were collected in the course of a survey among Swiss enterprises in the year 2009 using a questionnaire specifically designed for this survey that included besides questions on some basic firm characteristics (sales, exports, employment, investment and employees' vocational education), questions on energy-saving activities as well as on motives and obstacles of such activities.[8] The survey was based on a (with respect to firm size) disproportionately stratified random sample of firms with at least 5 employees covering all relevant industries of the manufacturing sector, the construction sector and selected service industries (on the whole 29 industries and within each industry three industry-specific firm size classes with full coverage of large firms). The final data set includes 2324 enterprises from all fields of activity and size classes (see table A.1 in the appendix for the structure of the used data set by industry and firm size respectively)[9].

4. Descriptive analysis

4.1 Preliminary remarks

Based on information of the International Energy Agency (see IEA 2008) we distinguished four groups of energy-saving technology applications (see table 2a and table 2b): (a) electromechanical and electronic applications (e.g., energy-saving in machines either by substitution for more energy efficient machines or by modification of already installed machines towards more energy efficiency); (b) applications specific to motor vehicles and traffic engineering; (c) applications in building construction; and (d) applications in power-generating processes. Each of these four main groups of energy-saving technology applications were further divided to more specific categories of applications, e.g., we distinguish under the heading applications of type (d) heat pumps, heat recuperation systems and combined heat-and-power generation based on biomass or gas/ carbon. We measure *inter-firm* diffusion by the binary variable "adoption of at least one energy-saving technology application in one of the technology fields defined in table 2a in a certain point of time: yes/no" (see also table 1a). *Intra-firm* diffusion is measured by the number of technology applications of a certain technology field defined in table 2a adopted by the firm in a certain point of time (see also table 1a).

4.2 Inter-firm diffusion

On the whole more than 50% of all responding firms reported at least one of the energy-saving technology application defined in table 2a and table 2b. About half of them (51.1%,

[8] Versions of the questionnaire in German, French and Italian are available at www.kof.ethz.ch.
[9] Table A.2 in the appendix shows the descriptive statistics for all variables used in this study; table A.3 shows the respective correlations matrix.

i.e. 27.3% of all firms) have introduced such technologies already before 2004. 92.3% of technology adopting firms, i.e. 49.3% of all firms, have either introduced such technologies for the first time or expanded the use of them in the year 2004 and later. A similar pattern is found also for most of single technology applications. In sum, according to these data the adoption of energy-saving technologies is a rather new phenomenon. Inter-firm diffusion has been intensified in the last five years.

The most frequently reported applications were related to building construction (type (b); 45.0% of all firms). 70.5% of such applications (i.e. 31.7% of all firms) referred to building lighting; building heating (69.1%, i.e. 31.1% of all firms) has been an equally important domain for energy-saving. The high percentage of such technology applications can be explained by the fact that building-related energy-saving is widely applicable in all sectors of the economy.

39.6% of all firms used energy-saving technology applications of category (a), primarily in components of process engineering (compressors, pumps, heat exchangers, etc.), electrical machines and drive systems as well as in information and communication technologies (about 62% of them in each sub-group, i.e. about 25% of all firms).

Energy-saving technology applications in transport (category (b); 18.3% of all firms) or power-generating processes (category (d); 21.7% of all firms) have been much less frequently introduced than energy-saving technologies in the categories (a) and (c). For category (d) is obvious that only for larger firms can be efficient to generate their own power and not buy it. It is remarkable that power-generating technologies based on non-fossil energy sources that also reduce CO_2-immissions are rather rare: only 5.0% of firms with applications of category (d) (i.e. 2.0 of all firms) reported the use of combined heat-and-power generation based on biomass.

The fact that many firms reported the use of energy-saving technology applications in more than one of the four technology categories considered in this study shows that a parallel use of such technology applications is a frequent firm practice that indicates a kind of complementarity of the different technology categories with respect to a total firm energy-saving goal.

All these technology applications reflect energy-saving in production processes as well as in products. Process applications are presumably dominant in the service industries and in manufacturing industries such as food, clothing and textile, wood processing, chemicals, plastics, metals and glass, stone and clay. Both types of applications are used in the industries producing primarily capital goods (machinery, electrical machinery, electronics and instruments and vehicles).

4.3 Intra-firm diffusion

In this study intra-firm diffusion cannot be measured as in studies referring to a single technology (for example, IT for E-commerce) by an intensity measure (for example, sales share by E-commerce). Thus, we apply a wider concept of intra-diffusion based on the number of technology applications (belonging to one of the four categories distinguished here) used in the firm.[10]

55.5% of the firms using technology applications of category (a) reported only 1 or 2 such applications, 44.5% of them 3, 4 or 5 such applications. The shares of firms with only 1 application for the other categories are: 58.5% (type (b)); 42.0% (type (c); and 63.6% for type (d)). These figures show that with the exception of technology applications for construction the intra-firm extent of usage of energy-saving technologies either in production processes or in products is rather limited. A possible explanation for this could be that most firms do not have integrated strategies of energy-saving (see, e.g., Santos da Silva and Amaral 2009) but invest occasionally in the one or the other application field. However, it is a common characteristic to many technologies after their early years that intra-firm diffusion is limited (see Canepa and Stoneman 2004).

5. Estimation method and empirical results

5.1 Inter-firm diffusion

5.1.1 Basic estimates

In a first step, we estimated a probit model for each of the four groups of energy-saving technology applications that were presented in section 4 (see table 3; table A.6 in the appendix shows the respective marginal effects). Table 1a shows the construction of the respective four binary variables, table 1b contains the explanatory variables in accordance with the model specification in section 2. Information on adoption motives was available only for adopting firms, therefore the probit estimates in table 3 that are based on all firms do not include the adoption motives as variables that measure adoption inducements.

Firm-specific rank effects.

We find to a large extent the same pattern with respect to the variables reflecting firm-specific rank effects for all four groups of energy-saving technology applications. Obviously the likelihood that at least one of the technology applications is adopted is driven by the same firm characteristics independent from the specific type of technology applications.

[10] Of course one could define other measures, e.g. number of technology categories or total number of technology applications. In this paper we restrict the analysis to this measure that we think has the larger information content.

Not all firm characteristics included in our variable vector are equally important for technology adoption. With respect to factor endowment the variable for gross investment per employee[11] and the dummy variable for R&D show the expected positive signs and the respective coefficients are statistically significant at the 10% test level. It is not astonishing that R&D activities are more important for electromechanical and electronic applications (group (a)) than for the other three types of technology applications (see the marginal effects in table A.6 in the appendix). Contrary to our expectations, adopting firms do not use more human capital than non-adopting firms. The insignificant coefficients of the variable HQUAL in table 3 indicate that in the case of energy-saving technologies not the percentage of employees with tertiary-level education but rather the existence of R&D activities constitutes a crucial precondition for adopting such new technologies.[12]

Firm size shows the expected (non-linear) positive effect. There are some differences among the various technology types with respect to foreign-owned firms. Foreign firms seem to be less inclined than domestic firms to adopt energy-saving technologies in buildings and energy-generating processes. A possible explanation for this effect is that foreign firms more often than domestic firms do not use own buildings or own energy-generation processes, thus they are not responsible for this kind of investment in energy-saving technologies.[13] Finally, export activities do not appear to be a specific trait of adopting firms.

Most of the studies with a similar theoretical background known to us investigate the diffusion of advanced manufacturing technologies or of information and communication technologies (ICT). For this reason we discuss in the next paragraph the similarities or differences of our results with respect to these studies, in the sense of a test of the range of the validity of the underlying common theoretical approach. In section 5.1.2 we discuss then some studies that deal specifically with the diffusion of energy-saving technologies but not use, at least explicitly, our theoretical approach.

Most empirical studies on advanced manufacturing technologies – this is one of the fields that have been most intensively investigated in empirical research on technology diffusion – also find positive effects of firm size on inter-firm diffusion (see Karshenas and Stoneman 1995 and Canepa and Stoneman 2004 for surveys of this literature). Recently, also studies on ICT diffusion show similar positive effects (see, e.g., Hollenstein 2004 and Bertschek and Fryges

[11] The equations in table 3 contain also the dummy variable INVEST/L_0 as control for firms with null gross investment in 2008.

[12] The possibility that multicollinearity effects due to the correlation between the variables R&D and HQUAL (r = 0.17) could be responsible for the insignificant coefficient for HQUAl was examined in estimates of all four equations without the variable R&D. The coefficient for R&D remained also in this case statistically insignificant at the 10% test-level. The slightly negative sign of the variable HQUAL in the estimates for the technology applications in group (d) (variable ENERGY) in table 3 is not robust, as the estimates of the multivariate probit model in column 4 in table 4 (as well as probit estimates without the variable R&D) showed.

[13] We tested the hypothesis that diffusion obstacles, particularly compatibility impediments, may restrain foreign firms stronger than domestic firms. To this end, we inserted in the equation for ENERGY interaction terms of the obstacle variables with the the dumy variable for foreign firms. Estimates not presented here showed no significant effect for the interaction terms.

2002). The evidence for the effect of human capital intensity shows also positive effects on inter-firm diffusion: for example, Battisti et al. (2007) and Battisti et al. (2009) found a positive effect on inter-firm diffusion of ICT for both Swiss and UK firms; Arvanitis and Hollenstein (2001) reported a positive effect on inter-firm diffusion of advanced manufacturing technologies. Less clear is the evidence for in-house R&D and/or innovative activities: these are found to be important by Battisti et al. (2007) for UK firms (but not for Swiss firms), Battisti et al. (2009) for UK firms, Hollenstein and Woerter (2008) and Arvanitis and Hollenstein (2001) for Swiss firms, Arundel and Sonntag 1999 for Canadian firms but not by Colombo and Mosconi (1995) for Italian firms. In sum, the firm-specific rank effects in this study are on the terms explained above in accordance to existing empirical literature.

Rank effects of market environment.

Competitive pressures as measured by the intensity of price competition (IPC) are relevant for at least two technology groups, electromechanical and electronic applications (variable MACHINE) and energy-generating processes (ENERGY), also for transport applications (TRANSPORT) (in the estimates in column 2 in table 4) but not for building applications (BUILDING). On the whole, competitive pressures seem to have some influence on the propensity to adopt energy-saving technologies, particularly for firms with substantial energy costs that use machinery intensively and/or generate their own power (electricity or heat).

Competitive pressures show positive effects on inter-firm diffusion partly in Hollenstein and Woerter (2008) (only for E-purchasing of Swiss firms), also partly in Dholakia and Kshetrei (2004) for US firms and in Arvanitis and Hollenstein (2001) (only for the intensity of non-price competition for Swiss firms) but not in Karshenas and Stoneman (1993) for the UK and Colombo and Mosconi (1995) for Italy.

The third variable that refers to influences of the market environment, the indicator for expected demand DEMAND, seems to be of minor importance (except for building-related technologies).

Stock, order and epidemic effects. The variables for *inter-firm* diffusion on industry level show positive and significant coefficients in all four equations. Similar effects were found also in earlier studies (see, e.g., Battisti et al. 2009; Hollenstein and Woerter 2008 (only for E-selling); Arvanitis and Hollenstein 2001; Colombo and Mosconi 1995). In contrast to this result, the coefficients for *intra-firm* diffusion on industry level ("cross-effect") are positive but statistical insignificant at the 10% test-level in three out of four equations in table 3, but significantly negative in the equation for adoption of technology applications in power-generating processes (ENERGY). This negative effect means that more intensive use of such technologies by other firms has a downward impact on the likelihood of such technologies being adopted. Existing similar literature has yielded mixed evidence: for example, Battisti et

al. (2009) found a positive effect; Hollenstein and Woerter (2008) could not find any significant effect.

In sum, inter-firm epidemic (learning) and network effects seem to outweigh negative effects of stock and order effects leading to positive net effects that enhance the inter-firm adoption rate of energy-saving technologies. This is not the case for intra-firm epidemic (and/or eventually network effects), with the exception of the ENERGY technology applications. Thus, for the introduction of energy-saving technologies relevant is the experience of first use of such technologies in other firms and in most cases not the intensity of usage (for example, the number and width of used technology applications).

Adoption costs. Adoption cots are only indirectly modelled in this study. Our model contains variables for four potential barriers that could increase adoption costs. Lack of compatibility with current product programme or current production technology seems to be the main barrier for firms that hinder them from adopting any kind of energy-saving technologies. The respective variable COMPT has a significantly negative coefficient in all four equations in table 3. Contrary to our expectations, we obtained significant but positive coefficients for the variables for financing obstacles (FIN) and for information and knowledge barriers (INFO) also in all four estimates. These findings mean that non-adopting firms seem to anticipate these two types of obstacles less as a problem than adopting firms. This is because technology adoption involves a learning process. Technology users face problems that they assessed to be less severe before the adoption and have to be solved during the adjustment process. We conclude that information on impediments in surveys should not be interpreted as impenetrable barriers. Rather, they often reflect a problem awareness that increases with experience in technology use (see Baldwin and Lin 2001 for a similar line of argumentation based on evidence for technology adoption in Canadian firms). Finally, the fourth group of potential barriers, organizational and managerial impediments, does not seem to have an influence on the adoption rate.[14]

Inducement effects. The level of the sales share of energy costs is positively correlated only with the propensity to adopt energy-saving technologies in power-generating processes. Further, we obtain a positive effect for the second variable for inducement effects ENV_AWARE (reflecting “intrinsic” motivation) in all four equations in table 3. Both results can be interpreted as hints that inducement effects are relevant for explaining the adoption rate of such technologies.

5.1.2 Empirical studies of adoption of energy-saving technologies

[14] Earlier studies using also variables for adoption impediments brought out rather heterogeneous results due to the heterogeneity of the impediments that were considered; see, e.g., Hollenstein and Woerter (2008); Dholakia and Kshetri (2004); Baldwin and Lin (2002); Arvanitis and Hollenstein (2001).

There are relatively few empirical studies dealing with the diffusion of energy-saving at firm level. Many of these studies do not use the theoretical background of this study (and of other similar studies) but concentrate on the investigation of barriers of diffusion of energy-saving technologies. We discuss here four of them that use firm data for more than one industry. In a study based on data for 285 larger US companies in three energy-intensive industries (plastics; petroleum; and steel) Pizer et al. (2002) investigated the determinants of the adoption of energy-saving technologies in the period 1991-1994. The factors that were found to enhance the adoption rate were firm size, profits and – to a smaller extent – energy prices, De Groot et al. (2001) found in a study for 135 Dutch firms for the year 1998 positive effects on the adoption rate for the energy intensity and the investment ratio in the horticulture industry, the investment ratio and mixed positive and negative effects for competitive pressures in the horticulture and the metal industry as well as the sub-sector of machinery, textiles and construction materials industry. Rather astonishingly, a positive firm size effect could be found only for the industry for basic metals. The most important barriers have been quite heterogeneous among industries: lack of compatibility with existing technologies (industry for basic metals; horticulture industry); organizational problems (horticulture industry); lack of internal financing (sub-sector of machinery, textiles and construction materials industry); lack of public subsidies (paper industry); and no need for further increase of energy efficiency (basic metals and food industry). In a further study for 110 Dutch firms Velthuijsen (1993) found that the following factors have been significant reasons for not implementing energy efficiency improvement opportunities: limited financial means; lack of information; no need to renew existing equipment; and lack of interest due to the fact that energy-saving do not belong to firms' core business. A study based on data for 50 Greek firms in 2004/2005 found that out of six industries primarily the metal industry suffered under a series of impediments such as lack of fund; high investment costs; high transaction costs; managerial deficiencies and uncertainty with respect to the development of energy prices (Sardianou 2008).

5.1.3 Extensions and robustness checks

In a second step, we took into consideration the interdependence among the adoption variables. To this end, we estimated a multivariate probit model, i.e. a simultaneous system of four adoption equations for the four different types of technology applications, instead of four separate probits. We applied the procedure implemented in STATA, which is based on the so-called GHK-simulator for multivariate distributions.[15] The results are presented in table 4. We found significant positive correlations between any pair of part-adoption equations. Thus, there is considerable empirical justification for estimating a multivariate probit model, even if

[15] The STATA procedure 'mprobit' estimates M-equation probit models by the method of simulated maximum likelihood. The Geweke-Hajivassiliou-Keane (GHK)-simulator is applied to evaluate the M-dimensional Normal integrals in the likelihood function (for a description of the GHK-simulator see Greene 2003).

the estimates in table 4 do not differ much from those in table 3. Small differences exist primarily with respect to the statistical significance of the dummy variables for the industrial sub-sectors. A further interesting point is that the positive correlations among the various categories of technology applications can be interpreted as a hint for the existence of complementarities among these technologies. This means that the different categories of technology applications are used parallel because they refer to different domains of enterprise functions and activities.[16]

In a third step, we took into account also the information about the *point in time* of the introduction of technology applications. Firms reported in our survey whether they introduced an energy-saving technology application before or after 2004. Based on this information, we constructed an ordinal variable for each of the four categories of energy-saving technology applications for non-adopting firms, "early" adopters and "late" adopters (3-level variable; see table 1a). Table 5 contains the ordered probit estimates for these variables. Distinguishing early and late adopters did not bring any new insights and the pattern of explanatory factors remains the same.

Data limitations do not allow tests of the potential endogeneity of some of the right-hand variables. However, in order to test model stability and potential bias we have estimated the model omitting the potentially endogenous variables (R&D; LN_INVEST/L; LN_ENEXP). We found that dropping the variables R&D and LN_ENEXP does not affect the other parameter estimates in any of the four equations. This is not the case for the variable LN_INVEST/L, the omission of which causes a significant increase of the coefficient of the variable DEMAND that cannot be traced back to multicollinearity because of the low correlation between these two variables (r=-0.121). Thus, the suspicion of endogeneity for the variable LN_INVEST/L cannot be removed.

5.2 Intra-firm diffusion

We estimated a multinomial logit model for each of the four groups of energy-saving technology applications that were presented in section 4 (see table 6).[17] [18] Table 1a shows the construction of the respective four dependent variables that contain three mutually exclusive groups of firms' states (non-adopting; "low-level" adopting; "high-level" adopting firms). We

[16] Complementarities between various advanced manufacturing technologies were found, for example, also in Colombo and Mosconi (1995); Stoneman and Toivanen (1997); and Arvanitis and Hollenstein (2001).

[17] We used a multinomial logit estimator after testing for the "Independence from Irrelevant Alternatives " (IIA assumption) (Hausman and McFadden 1984). We conducted Hausman tests for each of the eight coefficient vectors reported in table 6, and none of the associated chi-quadrate statistics hinted to a violation of the IIA assumption at any conventional level of statistical significance.

[18] We also estimated ordered probit models for 3 levels (and 3 to 5 levels dependent on the maximum number of single technology applications reported as adopted by a firm in one of the four categories of energy-saving technology applications; see table A.7 and table A.8 in the appendix). There are no differences between these estimates and the estimates for inter-firm adoption because the differences between adopting and non-adopting behaviour dominate the results in both cases, so that the intra-firm differences are not discernible.

chose level 1 as base level, so that the estimates reflect the comparison of "low-level" adopting behaviour either with non-adopting behaviour or "high-level" adopting behaviour. Table 1b contains the explanatory variables in accordance with the model specification in section 2. The columns 1, 3, 5 and 7 in table 6 contain the estimates for the comparison between non-adopting and "low-level" adopting behaviour. These estimates are qualitatively the same as those in the probit estimates in table 3 with the exception of the variables for intra-firm epidemic effects in the estimates for MACHINE and BILDING that have now rather unexpectedly positive signs, hinting to negative effects.

We concentrate here to the intra-firm effects ("high-level"-adopting versus "low-level" adopting behaviour) that are found in the columns 2, 4, 6 and 8 in table 6. There are significant differences from the pattern of relevant explanatory factors for inter-firm adoption found in table 3. Some of the factors that were important for the inter-firm adoption rate lost their importance for explaining the extent of usage of energy-saving technologies (see table 6). *Factor endowment* in the form of gross investment per employee and R&D showed no effect on the rate of intra-firm adoption, with the exception of rather weak positive effect of gross investment in the case of building-related technologies (BUILDING; column 3 in table 6). *Firm size* showed a positive effect in all four equations in table 6 also on intra-firm adoption. Foreign firms are less inclined than domestic firms to more intensive use of energy-saving technologies (with the exception of transport-related technologies). *Competitive pressures* remained also relevant but non-price competition appears to be more effective than price competition in the case of intra-firm adoption. It seems that more intensive usage of new technologies requests higher technological capabilities that are available mostly to firms that are stronger exposed to non-price competition with respect to qualitative and technological product characteristics.

The results with respect to the variables for *inter-firm* and *intra-firm external effects* are symmetrical to those for inter-firm diffusion. The intra-firm effects (direct effects) are significantly positive in three out of four types of technology applications, positive but statistically insignificant in the case of the fourth category (d) of power-generating technology applications (ENERGY). All four cross-effects (inter-firm) are insignificant. Therefore, also in the case of intra-firm adoption the direct epidemic (and/or eventually network effects) seem to outweigh stock and order effects, with the exception of power-generating technology applications. In the latter case no influence of external effects could be found.

As to *adoption barriers*, information and knowledge obstacles showed positive coefficients only for machinery-related technology applications. Financial and organizational barriers were of no relevance. Finally, compatibility barriers that appeared to be "proper" impediments of adoption in case of inter-firm diffusion changed the sign to positive in the equation for transport-related equation (column 4 in table 6) indicating now a problem

awareness that increases with more intensive technology use (see the discussion of such effects in section 5.1.1).

The sales share of energy costs is positively correlated with the rate of intra-firm adoption only in the equation for ENERGY, as it was the case also in the inter-firm estimates. The second variable for *inducement effects* reflecting the "intrinsic" motivation for adopting environment-friendly technologies (ENV_AWARE) has again a significantly positive coefficient throughout the estimates in the columns 2, 4, 6 and 8.

The evidence from comparable earlier studies[19] that investigated intra-firm diffusion is mixed. In general, most studies found that the firm-specific factors that explain inter-firm adoption and intra-firm adoption are not the same. For example, firm size can be positively, negatively or not correlated with the *intra-firm* adoption rate, while most studies find a positive correlation of firm size and *inter-firm* adoption rate. Further, the significance of the external effects differ from study to study substantially: For example Battisti et al. (2009) found negative effects of the inter-firm diffusion variable (on industry level) and positive effects of the intra-firm diffusion variables (on industry level) and Hollenstein and Woerter (2008) estimated significant positive coefficients only for the intra-firm variables. On the other hand, Battisti et al. (2007) found both for Switzerland and the UK positive effects of the intra-firm variable, but no effects for Switzerland and a negative effect for the UK for the inter-firm variable; the findings for Switzerland are in accordance with the results of this study. Finally, Battisti and Stoneman (2005) could not find any significant effects of external effects on intra-firm adoption. On the whole, the empirical findings for intra-firm adoption are more heterogeneous than those for inter-firm adoption. A first possible explanation for this difference could be that intra-firm dissemination of technology is much more idiosyncratic than inter-firm diffusion, thus depending much stronger than the latter on characteristics such as management abilities, organisation forms, etc.. A further explanation could be that the potential for the more intensive use of such divergent technologies is rather limited as compared, for example, with the utilization potential of ICT technologies.

5.3 Motives of intra-firm diffusion

In order to be able to use also the four variables for adoption inducements that were measured only for firms that have adopted at least one technology application in any of the four categories considered in this study, we estimated also a multinomial logit model for a sub-sample that contained only the firms with at least one technology application (table 7). For such a procedure of course the issue of potential selection bias of the estimate that are based on the sub-sample arises. A comparison of the results in table 6 (all firms) and table 7 (only adopting firms), particularly those for the level 2 (columns 2, 4, 6 and 8 in both tables) shows

[19] See our remarks to comparable literature in section 5.1.1.

that the estimates remain quite stable when the observations of non-adopting firms are removed from sample in the estimates in table 7. This is a clear hint that sample selection does not make a difference in this case. We also examined the selectivity bias issue in the framework of a bivariate probit model with sample selection (Heckman approach) for the variable MACHINE.[20] The selection as well as the intensity equation contained the same right-hand variables as in table 3 and table 6; the selection equation included as additional (identifying) variable the employment share of apprentices. The results (not presented here) showed no selection bias. As a consequence, the intensity equation could be estimated as a simple probit model. The results were qualitatively the same as those obtained for the multinomial model in table 7. This is additional evidence that the estimates in table 7 are quite robust.

Inserting the four variables for adoption motives that reflect inducement effects in the intra-firm adoption equations did not yield substantial new insights. Neither increasing energy prices and/or taxes nor public regulation and/or public incentives (with the exception of public regulation in the case of building technology applications; column 6 in table 7) seem to influence significantly the intra-firm adoption rate. However, for two categories of technology application, electromechanical and electronic applications (category (a)) and building applications (category (c)), we obtained a positive effect for the variable OTHER reflecting the following single motives: (1) current or expected demand for environment-friendly products (factor loading 0.66; see table A.5 in the appendix); (2) protection of environment ("intrinsic" motive; factor loading 0.47); and (3) uncertainty as to future energy bottlenecks (0.21). The single motives (1) and (2) with the higher factor loadings are primarily responsible for the positive effect of the variable OTHER in the estimates for MACHINE and BUILDING. These two single motives reflect two important inducements channels: an "intrinsic" one (positive valuing of environment protection) and a second one that is market intermediated (expected demand for environment-friendly products). These findings demonstrate, in addition to the effects of the variables ENV_AWARE and LN_ENEXP in table 6 and table 3 (for inter-firm adoption), that there are significant inducement effects, particularly effects related to intrinsic motives for the use of energy-saving technologies.

6. Summary and conclusions

Inter-firm diffusion. We find to a large extent the same pattern with respect to the variables reflecting firm-specific rank effects for all four groups of energy-saving technology applications we define in this study. Obviously the likelihood that at least one of these technology applications is adopted is driven by the same firm characteristics independent from the specific type of technology applications.

[20] We applied the heckprob procedure of STATA.

Not all firm characteristics included in our variable vector are equally important for technology adoption. With respect to factor endowment the variable for gross investment per employee and the dummy variable for R&D show the expected positive signs. Contrary to our expectations, adopting firms do not use more human capital than non-adopting firms. Firm size shows the expected (non-linear) positive effect. There are some differences among the various technology types with respect to foreign-owned firms. Foreign firms seem to be less inclined than domestic firms to adopt energy-saving technologies in buildings and energy-generating processes. Finally, export activities do not appear to be a specific trait of adopting firms. On the whole, competitive pressures seem to have some influence on the propensity to adopt energy-saving technologies, particularly for firms with substantial energy costs that use machinery intensively and/or generate their own power (electricity or heat).

Inter-firm epidemic (learning and, eventually, network effects) seem to outweigh negative stock and order effects leading to positive net effects that enhance the inter-firm adoption rate of energy-saving technologies. This is not the case for intra-firm epidemic and network effects; for this variable – with the exception of the ENERGY estimates – no significant effect could be found. Thus, relevant for the introduction of energy-saving technologies is the experience of first use of such technologies in other firms and in most cases not the intensity of usage (for example, the number and width of used technology applications).

Lack of compatibility with current product programme or current production technology seems to be the main barrier for firms that hinder them from adopting any kind of energy-saving technologies. Contrary to our expectations, we obtained significant but positive coefficients for the variables for financing obstacles and for information and knowledge barriers also in all four estimates. We conclude that information on impediments in surveys should not be interpreted as impenetrable barriers. Rather, they often reflect a problem awareness that increases with experience in technology use

Intra-firm diffusion. There are significant differences from the pattern of relevant explanatory factors for inter-firm adoption. Some of the firm-specific factors (rank effects) that are important for the inter-firm adoption rate loose their importance for explaining the extent of usage of energy-saving technologies. Factor endowment in the form of gross investment per employee and R&D show practically no effect on the rate of intra-firm adoption. Firm size shows a positive effect in three out of four equations for intra-firm adoption. Foreign firms are less inclined than domestic firms to more intensive use of energy-saving technologies (with the exception of transport-related technologies). Competitive pressures are still relevant but non-price competition appears to be more effective than price competition in the case of intra-firm adoption. The results with respect to the variables for the inter-firm and intra-firm external effects are symmetrical to those for inter-firm diffusion. The intra-diffusion effects (direct effects) are significantly positive in three out of four types of technology applications, positive but statistically insignificant in the case of the fourth category (d) of power-

generating technology applications. All four cross-effects (inter-diffusion) are insignificant. As to adoption costs, information and knowledge obstacles show positive coefficients for machinery-related and building-related technology applications. Financial and organizational barriers are of no relevance. Finally, compatibility barriers that appear to be "proper" impediments of adoption in case of inter-firm diffusion changed the sign to positive in the equation for transport-related equation.

Finally, positive *inducement effects,* particularly effects related to intrinsic motivation for using energy-saving technologies could be found for both inter-firm and intra-firm technology adoption.

Some implications for economic policy. If economic policy is to promote the spreading of energy-saving technologies there is much more to do to encourage the intra-firm than the inter-firm adoption of such technologies. The importance of rank effect indicates that the patterns of firm diffusion reflect the different strengths of firms with different characteristics. Thus, it is difficult to conceive a policy that fits to all firms. The heterogeneity of firms (for example, with respect to firm size or the existence of R&D activities) has to be taken into consideration when a promotion policy is formulated. On the other hand, we find almost the same pattern of diffusion for all four categories of technology applications. Thus, policy has to be specific to firm categories but not to technology types to be effective. Intrinsic motivation based on positive valuing of environmental protection is an important determinant of adoption that can be enhanced by policy measures. Finally, although our results are based only on a single cross-section of firms and are not definite, they yield some evidence that there exist *positive* technological (and eventually network externalities) in the diffusion of energy-saving technologies that would enhance the propensity as well as the extent of usage of such technologies.[21] For power-generating technology applications (category (d)) we could not find such externalities with respect to intra-firm adoption. In this case public promotion of information platforms, etc. that provide firms with information about the technical possibilities of energy-saving strategies in the framework of firm-specific integrated energy-saving programmes can be useful.

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[21] In the presence of such externalities firms with a „first adopter" profile may be discouraged to invest in the technology or invest sub-optimally if they are not able to appropriate all revenues from their investment. We cannot exclude this case but in our estimates (with just one exception) potential negative stock and order effects are outweighed by positive learning effects.

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Table 1a: Definition of the *dependent* variables

Variable	Description (reference year: 2008)
- Inter-firm Diffusion	
MACHINE	Binary variable: 1: adoption of at least one out of five technology applications listed under (a) in table 2a; 0: otherwise
TRANSPORT	Binary variable: 1: adoption of at least one out of three technology applications listed under (b) in table 2a; 0: otherwise
BUILDING	Binary variable: 1: adoption of at least one out of five technology applications listed under (c) in table 2a; 0: otherwise
ENERGY	Binary variable: 1: adoption of at least one out of four technology applications listed under (d) in table 2a; 0: otherwise
MACHINE_T	Ordinal variable: 2: adoption of at least one out of five technology applications listed under (a) in table 2a *before 2004*; 1: adoption *2004 and later*; 0: otherwise
TRANSPORT_T	Ordinal variable: 2: adoption of at least one out of three technology applications listed under (b) in table 2a *before 2004*; 1: adoption *2004 and later*; 0: otherwise
BUILDING_T	Ordinal variable: 2: adoption of at least one out of five technology applications listed under (c) in table 2a *before 2004*; 1: *adoption 2004 and later*; 0: otherwise
ENERGY_T	Ordinal variable: 2: adoption of at least one out of four technology applications listed under (c) in table 2a *before 2004*; 1: *adoption 2004 and later*; 0: otherwise
- Intra-firm Diffusion	
MACHINE_N_0	3-level ordinate variable: level 2: adoption of 3, 4 or 5 of the technology applications listed under (a) in table 2a; level 1: adoption of 1 or 2 of the technology applications listed under (a); level 0: otherwise
TRANSPORT_N_0	3-level ordinate variable (level 2: adoption of 2 or 3 of the technology applications listed under (b) in table 2a; level 1: adoption of 1 of the technology applications listed under (b); level 0: otherwise
BUILDING_N_0	3-level ordinate variable (level 2: adoption of 3, 4 or 5 of the technology applications listed under (c) in table 2a; level 1: adoption of 1 or 2 of the technology applications listed under (a); level 0: otherwise
ENERGY_N_0	3-level ordinate variable (level 2: adoption of 2, 3 or 4 of the technology applications listed under (d) in table 2a; level 1: adoption of 1 of the technology applications listed under (d); level 0: otherwise
MACHINE_N_5	5-level ordinate variable: 1, 2, 3, 4, 5 of the technology applications listed under (a) in table 2a; reference level: 0
TRANSPORT_N_3	3-level ordinate variable: 1, 2, 3 of the technology applications listed under (b) in table 2a; reference level: 0
BUILDING_N_5	5-level ordinate variable: 1, 2, 3, 4, 5 of the technology applications listed under (c) in table 2a; reference level: 0
ENERGY_N_4	4-level ordinate variable: 1, 2, 3, 4 of the technology applications listed under (d) in table 2a; reference level: 0

Table 1b: Definition of the *independent* variables

Variable	Description
Independent variables	
- Firm-specific rank effects	
LN_EMPL	Natural logarithm of the number of employees (in full-time equivalents) by the end of the year 2008
LN_INVEST/L	Natural logarithm of gross investment expenditure per employee (value null for firms with null gross investment) in the year 2008
INVEST/L_0	Dummy variable for firms with null gross investment in the year 2008
HQUAL	Employment share of employees with tertiary-level education by the end of the year 2008
R&D	R&D activities yes/no (dummy variable) in the period 2006-2008
EXPORT	Export activities yes/no in the year 2008
FOREIGN	Foreign-owned firm yes/no (dummy variable)
- Rank effects as to a firm's market environment	
DEMAND_EXPECT	Expected change of demand for a firm' s main product for the period 2009-2011 (5-level ordinate variable based on a five-point intensity scale: values 1 to 5)
IPC	Intensity of *price* competition (5-level ordinate variable based on a five-point intensity scale: values 1 to 5)
INPC	Intensity of *non-price* competition (5-level ordinate variable based on a five-point intensity scale: values 1 to 5)
IND1-IND7	Subsectors: IND1: NACE 22, 335, 36, 37; IND2: NACE 21, 23, 24, 25, 26, 27, 28, 40, 41; IND3: NACE 29, 31, 30, 31, 32, 331-334, 34, 35 ; IND4: NACE 45; IND5: 50, 51, 52; IND6: 55, 60-63, 70, 71; IND7: 64, 65-67, 72, 73, 74, 93; reference: NACE 15-20
- Epidemic effects	
= Inter-firm	
INTER_MACHINE	Share of firms adopting at least one out of 5 technology applications listed under (a) in table 1 by *2-digit industry*
INTER_TRASPORT	Share of firms adopting at least one out of 3 technology applications listed under (b) in table 1 by *2-digit industry*
INTER_BUILDING	Share of firms adopting at least one out of 5 technology applications listed under (c) in table 1 by *2-digit industry*
INTER_ENERGY	Share of firms adopting at least one out of 4 technology applications listed under (d) in table 1 by *2-digit industry*
= Intra-firm	
INTRA_MACHINE	Mean of adopted technology applications listed under (a) in table 1 (only adopting firms) by *2-digit industry*
INTRA_TRANSPORT	Mean of adopted technology applications listed under (b) in table 1 (only adopting firms) by *2-digit industry*
INTRA_BUILDING	Mean of adopted technology applications listed under (c) in table 1 (only adopting firms) by *2-digit industry*
INTRA_ENERGY	Mean of adopted technology applications listed under (d) in table 1

	(only adopting firms) by *2-digit industry*
- Adoption costs	
Barriers of adoption:	Factor values; see table A.4 in the appendix
INFO	Information and knowledge barriers: uncertainty with respect to technology performance, uncertainty about the future price development
COMPAT	Adjustment barriers: lack of compatibility with current product programme or current production technology
FIN	Financing barriers: high investment expenditures, liquidity constraints
ORGAN	Organizational and managerial barriers: lack of know-how, of specialized personnel, of management attention
- Inducement effects	
LN_ENEXP	Natural logarithm of the sales share of energy costs (value null for firms with null sales share) in the year 2008
ENEXP_0	Dummy variable for firms with null sales share
ENV_AWARE	Environmental criteria are taken into consideration for purchases of intermediate inputs (5-level ordinate variable based on a five-point intensity scale: values 1 to 5)
Motives of adoption:	Factor values; see table A.5 in the appendix
PRICE_TAX	Current and / or expected increases of energy prices and / or energy taxes
PUBLIC_INCENT	Public incentives for energy efficiency and / or CO2 reduction
PUBLIC_REGUL	Public regulations and /or agreements between firms and government agencies concerning energy efficiency
OTHER	Demand for environment-friendly products; expected energy bottle-necks

Table 2a: Inter-firm diffusion of energy-saving technologies

Type of energy-saving technology application	Number and share of adopters; total		Number and share of adopters; before 2004		Number and share of adopters; 2004 and later	
	N	%	N	%	N	%
(a) Energy-saving technologies in electromechanical and electronic applications, namely(*):	*914*	*39.6*	*335*	*14.5*	*817*	*35.4*
- in electrical machines and drive systems	567	24.6	172	7.5	465	20.2
- in information and communication technologies	554	24.0	106	4.6	484	21.0
- in consumer electronics	213	9.2	76	3.3	146	6.3
- in components of process engineering (e.g., compressors; pumps; heat exchangers)	577	25.0	193	8.4	448	19.4
- in process engineering	358	15.5	115	5.0	285	12.4
(b) Energy-saving technologies in motor vehicles and in traffic engineering, namely(*):	*421*	*18.3*	*121*	*5.2*	*365*	*15.8*
- in engines of motor vehicles	369	16.0	83	3.6	314	13.6
- in motor vehicle bodies (e.g., through the decrease of weight; the improvement of aerodynamics)	164	7.1	63	2.7	109	4.7
- in traffic management system	138	6.0	44	1.9	99	4.3
(c) Energy-saving technologies in buildings, namely(*):	*1038*	*45.0*	*424*	*18.4*	*896*	*38.9*
- in temperature isolation	631	27.4	211	9.2	468	20.3
- in lighting (incl. respective control systems)	732	31.7	171	7.4	601	26.1
- in heating (incl. respective control systems)	717	31.1	246	10.7	508	22.0
- in cooling systems	468	20.3	145	6.3	350	15.2
- in air ventilation and air conditioning	562	24.4	176	7.6	419	18.2
(d) Energy-saving technologies in power-generating processes, namely(*):	*501*	*21.7*	*241*	*10.5*	*347*	*15.0*
- Combined heat and power generation based on *biomass*	25	1.1	10	0.4	18	0.8
- Combined heat and power generation based on *oil / gas / carbon*	83	3.6	53	2.3	45	2.0
- Heat pumps	223	9.7	98	4.2	147	6.4
- Heat recuperation systems	406	17.6	186	8.1	267	11.6
Share of adopters with respect to all technology applications	*1231*	*53.4*	*629*	*27.3*	*1137*	*49.3*

Notes: (1): shares of firms with at *least 1 technology application* in the respective type of technology applications; reference: all firms. The shares for the single applications are percentages of technology adopting firms.

Table 2b: Intra-firm diffusion of energy-saving technologies

Type of energy-saving technology application	Number and share of adopters;		Number and share of adopters;	
	N	%	N	%
	With 1 or 2 technology applications		With 3, 4 or 5 technology applications	
(a) Energy-saving technologies in electromechanical and electronic applications	507	22.0	407	17.6
	With 1 technology application		With 2 or 3 technology applications	
(b) Energy-saving technologies in motor vehicles and in traffic engineering	245	10.6	176	7.6
	With 1 or 2 technology applications		With 3, 4 or 5 technology applications	
(c) Energy-saving technologies in buildings	440	19.1	598	25.9
	With 1 technology applications		With 2, 3 or 4 technology applications	
(d) Energy-saving technologies in energy-generating Processes	318	13.8	183	7.9

Notes: Shares of firms; reference: all firms.

Table 3: Determinants of inter-firm adoption of several types of energy-saving technologies; probit estimates

Explanatory variables	MACHINE		TRANSPORT		BUILDING		ENERGY	
LN_EMPL	0.180 ***	(0.022)	0.162 ***	(0.024)	0.254 ***	(0.023)	0.220 ***	(0.025)
LN_INVEST/L	0.092 ***	(0.025)	0.053 *	(0.029)	0.100 ***	(0.025)	0.210 ***	(0.030)
INVEST/L_0	0.429	(0.311)	-0.172	(0.419)	0.460	(0.311)	1.500 ***	(0.404)
HQUAL	-0.000	(0.002)	-0.003	(0.002)	-0.002	(0.002)	-0.004 *	(0.002)
LN_ENEXP	0.031	(0.029)	-0.014	(0.033)	-0.027	(0.030)	0.070 **	(0.034)
ENEXP_0	-0.476 ***	(0.177)	-0.419 *	(0.214)	-0.300 *	(0.165)	-0.291	(0.213)
R&D	0.436 ***	(0.076)	0.191 **	(0.088)	0.283 ***	(0.077)	0.305 ***	(0.083)
FOREIGN	0.014	(0.087)	-0.168	(0.103)	-0.213 **	(0.088)	-0.230 **	(0.100)
EXPORT	-0.014	(0.075)	-0.119	(0.085)	0.010	(0.075)	0.023	(0.087)
ENV_AWARE	0.226 ***	(0.030)	0.156 ***	(0.034)	0.184 ***	(0.030)	0.163 ***	(0.034)
DEMAND_EXPECT	0.051	(0.037)	0.008	(0.043)	0.106 ***	(0.037)	0.062	(0.043)
INFO	0.152 ***	(0.030)	0.143 ***	(0.035)	0.232 ***	(0.031)	0.091 ***	(0.035)
COMPAT	-0.242 ***	(0.030)	-0.129 ***	(0.035)	-0.255 ***	(0.030)	-0.214 ***	(0.035)
FIN	0.213 ***	(0.031)	0.135 ***	(0.036)	0.290 ***	(0.031)	0.139 ***	(0.036)
ORGAN	0.040	(0.030)	0.013	(0.034)	0.012	(0.030)	-0.025	(0.034)
IPC	0.082 ***	(0.031)	0.054	(0.035)	0.041	(0.031)	0.069 *	(0.035)
INPC	0.027	(0.033)	-0.019	(0.038)	0.042	(0.034)	-0.009	(0.038)
IND1	-0.060	(0.202)	0.149	(0.212)	-0.046	(0.187)	0.110	(0.210)
IND2	-0.048	(0.139)	0.101	(0.175)	0.051	(0.130)	0.134	(0.143)
IND3	-0.081	(0.158)	0.202	(0.191)	0.007	(0.146)	0.141	(0.165)
IND4	0.111	(0.224)	0.255	(0.186)	0.200	(0.180)	0.596 **	(0.284)
IND5	0.044	(0.220)	0.281 *	(0.164)	0.204	(0.172)	0.447 **	(0.226)
IND6	-0.005	(0.189)	0.024	(0.174)	0.135	(0.149)	0.288	(0.221)
IND7	0.100	(0.225)	0.304 *	(0.175)	0.272	(0.178)	0.571 **	(0.242)
INTER_MACHINE	1.711 **	(0.685)						
INTRA_MACHINE	-0.095	(0.213)						
INTER_TRANSPORT			3.405 ***	(0.429)				
INTRA_TRANSPORT			0.144	(0.228)				
INTER_BUIDING					1.778 ***	(0.642)		
INTRA_BUIDING					-0.021	(0.146)		
INTER_ENERGIE							3.300 ***	(0.629)
INTRA_ENERGIE							-0.921 **	(0.374)
Const.	-3.774 ***	(0.668)	-3.761 ***	(0.580)	-4.189 ***	(0.539)	-4.448 ***	(0.527)
No. of obs.	2285		2285		2285		2285	
Pseudo-R2	0.183		0.149		0.209		0.215	
LR chi2	560.2		323.3		656.7		515.0	
p-Value	0.000		0.000		0.000		0.000	

Notes: See table 1a and 1b for the definition of the variables. ***, **, * denote statistical significance at the 1%, 5% and 10% test level.

Table 4: Determinants of inter-firm adoption of several types of energy-saving technologies; tetravariate probit estimates

Explanatory variables	MACHINE		TRANSPORT		BUILDING		ENERGY	
LN_EMPL	0.180 ***	(0.022)	0.163 ***	(0.024)	0.247 ***	(0.023)	0.214 ***	(0.024)
LN_INVEST/L	0.089 ***	(0.025)	0.053 *	(0.029)	0.101 ***	(0.024)	0.209 ***	(0.029)
INVEST/L_0	0.426	(0.304)	-0.066	(0.397)	0.531 *	(0.294)	1.632 ***	(0.381)
HQUAL	0.000	(0.002)	-0.003	(0.002)	-0.002	(0.002)	-0.002	(0.002)
LN_ENEXP	0.030	(0.029)	-0.020	(0.032)	-0.029	(0.028)	0.062 *	(0.033)
ENEXP_0	-0.428 **	(0.167)	-0.439 **	(0.207)	-0.310 **	(0.157)	-0.294	(0.212)
R&D	0.398 ***	(0.076)	0.195 **	(0.085)	0.261 ***	(0.076)	0.304 ***	(0.082)
FOREIGN	0.004	(0.086)	-0.131	(0.100)	-0.188 **	(0.085)	-0.187 *	(0.095)
EXPORT	0.006	(0.075)	-0.120	(0.083)	0.028	(0.073)	0.027	(0.085)
ENV_AWARE	0.230 ***	(0.030)	0.147 ***	(0.033)	0.181 ***	(0.029)	0.156 ***	(0.033)
DEMAND_EXPECT	0.056	(0.037)	-0.002	(0.042)	0.104 ***	(0.036)	0.056	(0.041)
INFO	0.151 ***	(0.031)	0.147 ***	(0.035)	0.220 ***	(0.030)	0.103 ***	(0.034)
COMPAT	-0.246 ***	(0.030)	-0.139 ***	(0.034)	-0.237 ***	(0.030)	-0.213 ***	(0.034)
FIN	0.215 ***	(0.031)	0.152 ***	(0.036)	0.277 ***	(0.031)	0.143 ***	(0.035)
ORGAN	0.039	(0.030)	0.013	(0.033)	0.007	(0.029)	-0.023	(0.033)
IPC	0.081 ***	(0.031)	0.057 *	(0.034)	0.040	(0.030)	0.063 *	(0.034)
INPC	0.032	(0.033)	-0.027	(0.037)	0.048	(0.032)	-0.010	(0.037)
IND1	0.097	(0.196)	0.089	(0.204)	0.068	(0.180)	0.077	(0.202)
IND2	0.024	(0.136)	0.049	(0.165)	0.101	(0.127)	0.085	(0.138)
IND3	0.014	(0.153)	0.169	(0.180)	0.055	(0.140)	0.132	(0.158)
IND4	0.241	(0.211)	0.191	(0.180)	0.318 *	(0.174)	0.579 **	(0.266)
IND5	0.230	(0.209)	0.265 *	(0.158)	0.348 **	(0.163)	0.464 **	(0.214)
IND6	0.114	(0.182)	-0.033	(0.168)	0.168	(0.144)	0.282	(0.208)
IND7	0.223	(0.213)	0.259	(0.168)	0.327 *	(0.168)	0.543 **	(0.226)
INTER_MACHINE	2.103 ***	(0.610)						
INTRA_MACHINE	-0.070	(0.181)						
INTER_TRANSPORT			3.624 ***	(0.404)				
INTRA_TRANSPORT			0.119	(0.210)				
INTER_BUIDING					1.998 ***	(0.571)		
INTRA_BUIDING					0.073	(0.122)		
INTER_ENERGIE							3.336 ***	(0.580)
INTRA_ENERGIE							-0.789 **	(0.335)
Const.	-4.139 ***	(0.613)	-3.652 ***	(0.547)	-4.635 ***	(0.493)	-4.550 ***	(0.492)
No. of obs.	2285							
Pseudo-R2								
LR chi2	1096.7							
p-Value	0.000							
Estimated Residual Correlation Coefficients:								
Rho21	0.578 ***	(0.031)						
Rho31	0.725 ***	(0.020)						
Rho41	0.533 ***	(0.031)						
Rho32	0.545 ***	(0.031)						
Rho42	0.291 ***	(0.038)						
Rho43	0.632 ***	(0.029)						

Notes: See table 1a and 1b for the definition of the variables. ***, **, * denote statistical significance at the 1%, 5% and 10% test level.

Table 5: Determinants of inter-firm adoption of several types of energy-saving technologies (adoption point in time); ordered probit estimates

Explanatory variables	MACHINE_T		TRANSPORT_T		BUILDING_T		ENERGY_T	
LN_EMPL	0.172 ***	(0.020)	0.144 ***	(0.023)	0.203 ***	(0.020)	0.211 ***	(0.023)
LN_INVEST/L	0.082 ***	(0.023)	0.064 **	(0.028)	0.063 ***	(0.022)	0.188 ***	(0.029)
INVEST/L_0	0.318	(0.291)	-0.020	(0.402)	0.151	(0.284)	1.307 ***	(0.385)
HQUAL	-0.000	(0.002)	-0.003	(0.002)	-0.002	(0.002)	-0.002	(0.002)
LN_ENEXP	0.031	(0.027)	-0.021	(0.032)	-0.021	(0.026)	0.079 **	(0.032)
ENEXP_0	-0.461 ***	(0.167)	-0.427 **	(0.209)	-0.257 *	(0.151)	-0.330	(0.205)
R&D	0.380 ***	(0.068)	0.240 ***	(0.084)	0.239 ***	(0.068)	0.309 ***	(0.079)
FOREIGN	-0.033	(0.078)	-0.163	(0.100)	-0.198 **	(0.077)	-0.260 ***	(0.095)
EXPORT	-0.005	(0.068)	-0.150 *	(0.082)	-0.003	(0.066)	0.023	(0.083)
ENV_AWARE	0.200 ***	(0.027)	0.143 ***	(0.032)	0.155 ***	(0.026)	0.155 ***	(0.033)
DEMAND_EXPECT	0.034	(0.034)	0.001	(0.041)	0.095 ***	(0.033)	0.045	(0.041)
INFO	0.137 ***	(0.028)	0.130 ***	(0.034)	0.214 ***	(0.027)	0.080 **	(0.033)
COMPAT	-0.213 ***	(0.028)	-0.111 ***	(0.033)	-0.197 ***	(0.027)	-0.201 ***	(0.033)
FIN	0.191 ***	(0.028)	0.127 ***	(0.035)	0.243 ***	(0.028)	0.151 ***	(0.035)
ORGAN	0.029	(0.027)	0.004	(0.033)	0.019	(0.026)	-0.013	(0.032)
IPC	0.060 **	(0.028)	0.052	(0.034)	0.048 *	(0.027)	0.055	(0.034)
INPC	0.020	(0.030)	-0.007	(0.037)	0.032	(0.030)	-0.016	(0.036)
IND1	0.002	(0.182)	0.120	(0.203)	-0.091	(0.165)	0.181	(0.199)
IND2	0.028	(0.121)	0.054	(0.168)	0.003	(0.112)	0.142	(0.133)
IND3	-0.031	(0.141)	0.138	(0.183)	-0.081	(0.127)	0.143	(0.156)
IND4	0.101	(0.203)	0.212	(0.177)	0.107	(0.161)	0.640 **	(0.272)
IND5	0.053	(0.199)	0.218	(0.157)	0.009	(0.152)	0.503 **	(0.216)
IND6	0.057	(0.171)	-0.020	(0.165)	0.067	(0.131)	0.339	(0.211)
IND7	0.110	(0.203)	0.214	(0.167)	0.084	(0.157)	0.615 ***	(0.231)
INTER_MACHINE	1.410 **	(0.612)						
INTRA_MACHINE	0.015	(0.191)						
INTER_TRANSPORT			3.095 ***	(0.408)				
INTRA_TRANSPORT			0.235	(0.218)				
INTER_BUIDING					1.000 *	(0.567)		
INTRA_BUIDING					0.047	(0.129)		
INTER_ENERGIE							3.212 ***	(0.596)
INTRA_ENERGIE							-0.963 ***	(0.351)
cut1	3.554 ***	(0.601)	3.779 ***	(0.555)	3.279 ***	(0.469)	4.016 ***	(0.489)
cut2	4.504 ***	(0.603)	4.606 ***	(0.558)	4.197 ***	(0.471)	4.615 ***	(0.491)
No. of obs.	2285		2285		2285		2285	
Pseudo-R2	0.131		0.117		0.126		0.166	
LR chi2	556.1		312.1		571.3		510.6	
p-Value	0.000		0.000		0.000		0.000	

Notes: See table 1a and 1b for the definition of the variables. ***, **, * denote statistical significance at the 1%, 5% and 10% test level.

Table 6: Determinants of intra-firm adoption of several types of energy-saving technologies; multinomial logit estimates

	MACHINE_N_0				TRANSPORT_N_0				BUILDING_N_0				ENERGY_N_0			
	0		2		0		2		0		2		0		2	
LN_EMPL	-0.201 ***	(0.043)	0.252 ***	(0.052)	-0.244 ***	(0.053)	0.119 *	(0.071)	-0.287 ***	(0.048)	0.249 ***	(0.051)	-0.312 ***	(0.051)	0.227 ***	(0.070)
LN_INVEST/L	-0.159 ***	(0.045)	0.002	(0.059)	-0.134 **	(0.060)	-0.038	(0.086)	-0.127 ***	(0.047)	0.097 *	(0.055)	-0.322 ***	(0.059)	0.098	(0.091)
HQUAL	-0.001	(0.003)	-0.004	(0.004)	0.010 **	(0.005)	0.008	(0.007)	0.004	(0.004)	-0.002	(0.004)	0.009 **	(0.004)	0.009	(0.006)
LN_ENEXP	-0.076	(0.055)	0.065	(0.068)	0.026	(0.066)	0.133	(0.096)	0.023	(0.058)	0.036	(0.065)	-0.085	(0.066)	0.208 **	(0.095)
R&D	-0.638 ***	(0.146)	0.192	(0.174)	-0.182	(0.191)	0.446	(0.279)	-0.341 **	(0.157)	0.287 *	(0.169)	-0.490 ***	(0.166)	0.137	(0.243)
FOREIGN	-0.154	(0.161)	-0.368 *	(0.201)	0.263	(0.224)	-0.215	(0.346)	0.172	(0.176)	-0.343 *	(0.194)	0.175	(0.192)	-0.776 **	(0.317)
EXPORT	0.106	(0.143)	0.183	(0.182)	0.080	(0.187)	-0.300	(0.271)	-0.021	(0.153)	-0.040	(0.172)	0.002	(0.175)	0.089	(0.262)
ENV_AWARE	-0.310 ***	(0.058)	0.205 ***	(0.076)	-0.198 ***	(0.074)	0.223 **	(0.111)	-0.182 ***	(0.060)	0.254 ***	(0.070)	-0.223 ***	(0.070)	0.231 **	(0.109)
DEMAND_EXPECT	-0.098	(0.071)	-0.006	(0.089)	-0.016	(0.092)	0.030	(0.135)	-0.175 **	(0.076)	0.032	(0.085)	-0.113	(0.086)	0.001	(0.128)
INFO	-0.198 ***	(0.059)	0.166 **	(0.076)	-0.204 ***	(0.076)	0.130	(0.112)	-0.337 ***	(0.064)	0.112	(0.072)	-0.190 ***	(0.071)	-0.081	(0.104)
COMPAT	0.427 ***	(0.059)	0.039	(0.075)	0.323 ***	(0.075)	0.214 *	(0.109)	0.371 ***	(0.063)	-0.115	(0.070)	0.398 ***	(0.071)	0.031	(0.107)
FIN	-0.370 ***	(0.060)	-0.016	(0.079)	-0.265 ***	(0.079)	-0.081	(0.117)	-0.550 ***	(0.066)	-0.119	(0.075)	-0.295 ***	(0.073)	-0.136	(0.111)
ORGAN	-0.076	(0.057)	-0.025	(0.072)	-0.016	(0.073)	0.042	(0.107)	-0.087	(0.061)	-0.122 *	(0.068)	0.041	(0.068)	-0.011	(0.101)
IPC	-0.131 **	(0.060)	0.004	(0.074)	-0.138 *	(0.077)	-0.106	(0.108)	-0.019	(0.063)	0.088	(0.070)	-0.052	(0.070)	0.205 *	(0.107)
INPC	-0.061	(0.065)	-0.037	(0.080)	0.099	(0.082)	0.171	(0.119)	-0.007	(0.068)	0.131 *	(0.076)	0.064	(0.076)	0.193 *	(0.112)
IND1	0.164	(0.387)	-0.007	(0.465)	-0.273	(0.484)	0.269	(0.704)	0.010	(0.377)	-0.133	(0.423)	-0.130	(0.409)	0.018	(0.645)
IND2	0.199	(0.268)	0.215	(0.290)	-0.150	(0.427)	-0.139	(0.548)	-0.093	(0.264)	-0.008	(0.276)	-0.216	(0.269)	-0.042	(0.388)
IND3	0.245	(0.308)	0.195	(0.351)	-0.282	(0.457)	0.352	(0.615)	-0.126	(0.292)	-0.172	(0.316)	-0.178	(0.319)	-0.022	(0.486)
IND4	-0.114	(0.440)	0.117	(0.527)	-0.411	(0.423)	0.509	(0.568)	-0.224	(0.364)	0.176	(0.415)	-0.727	(0.579)	0.536	(0.889)
IND5	0.049	(0.424)	0.080	(0.518)	-0.378	(0.387)	0.629	(0.505)	-0.195	(0.351)	0.243	(0.392)	-0.512	(0.453)	0.408	(0.709)
IND6	0.103	(0.364)	-0.006	(0.440)	0.201	(0.417)	0.483	(0.552)	-0.276	(0.299)	-0.135	(0.326)	-0.316	(0.438)	0.154	(0.687)
IND7	0.093	(0.440)	0.205	(0.530)	-0.579	(0.412)	0.180	(0.555)	-0.502	(0.360)	-0.150	(0.402)	-0.858 *	(0.483)	0.197	(0.742)
INTER_MACHINE	-2.974 **	(1.318)	-0.495	(1.549)												
INTRA_MACHINE	0.925 **	(0.447)	1.509 ***	(0.502)												
INTER_TRANSPORT					-5.708 ***	(0.958)	0.338	(1.387)								
INTRA_TRANSPORT					0.750	(0.542)	2.962 ***	(0.712)								
INTER_BUILDING									-3.165 **	(1.294)	-0.713	(1.446)				
INTRA_BUILDING									0.677 **	(0.304)	1.195 ***	(0.334)				

INTER_ENERGY							-5.174 *** (1.239)	0.531 (1.881)
INTRA_ENERGY							1.815 ** (0.744)	0.755 (1.061)
Const.	4.388 *** (1.344)	-5.770 *** (1.558)	5.271 *** (1.316)	-6.961 *** (1.831)	4.257 *** (1.120)	-6.747 *** (1.225)	6.186 *** (1.049)	-6.584 *** (1.511)
No. of obs. (total)	2285		2285		2285		2285	
Pseudo-R2	0.152		0.141		0.169		0.188	
LR chi2	653.1		386.0		767.1		571.0	
p-Value	0.000		0.000		0.000		0.000	

Notes: See table 1a and 1b for the definition of the variables; base group: firms with 1 or 2 technology applications for MACHINE_N_0; firms with only 1 technology application for TRASPORT_N_0; BUILDING_N_0; and ENERG_N_0. Due to technical reasons the dummy variables ENEXP_0 and INVEST_0 were dropped. ***, **, * denote statistical significance at the 1%, 5% and 10% test level.

Table 7: Determinants of intra-firm adoption of several types of energy-saving technologies; multinomial logit estimates including *adoption motives* (only adopting firms

	MACHINE_N_0(*)				TRANSPORT_N_0(*)				BUILDING_N_0(*)				ENERGY_N_0(*)			
	0		2		0		2		0		2		0		2	
LN_EMPL	0.046	(0.057)	0.237 ***	(0.053)	-0.089	(0.057)	0.111	(0.073)	-0.135 *	(0.071)	0.252 ***	(0.052)	-0.173 ***	(0.055)	0.232 ***	(0.071)
LN_INVEST/L	-0.031	(0.059)	0.008	(0.060)	-0.021	(0.066)	-0.012	(0.088)	0.016	(0.070)	0.106 *	(0.056)	-0.264 ***	(0.065)	0.119	(0.094)
HQUAL	-0.003	(0.005)	-0.003	(0.004)	0.011 **	(0.005)	0.009	(0.007)	0.010 *	(0.005)	-0.002	(0.004)	0.008 *	(0.005)	0.008	(0.006)
LN_ENEXP	-0.146 *	(0.075)	0.051	(0.070)	0.037	(0.073)	0.128	(0.100)	0.120	(0.089)	0.033	(0.067)	-0.097	(0.073)	0.204 **	(0.096)
R&D	-0.682 ***	(0.205)	0.159	(0.177)	0.004	(0.200)	0.429	(0.283)	-0.015	(0.231)	0.282	(0.173)	-0.233	(0.180)	0.200	(0.245)
FOREIGN	-0.539 **	(0.234)	-0.353 *	(0.206)	0.054	(0.235)	-0.138	(0.350)	0.263	(0.254)	-0.266	(0.198)	0.113	(0.208)	-0.709 **	(0.319)
EXPORT	0.104	(0.196)	0.211	(0.187)	0.033	(0.202)	-0.286	(0.276)	-0.283	(0.234)	-0.069	(0.177)	-0.025	(0.193)	0.071	(0.268)
ENV_AWARE	-0.288 ***	(0.082)	0.169 **	(0.081)	-0.017	(0.084)	0.244 **	(0.117)	0.022	(0.095)	0.186 **	(0.074)	-0.032	(0.080)	0.187	(0.115)
DEMAND_EXPECT	0.001	(0.099)	-0.032	(0.093)	0.101	(0.101)	0.007	(0.140)	-0.247 **	(0.116)	0.011	(0.088)	-0.055	(0.095)	-0.014	(0.130)
INFO	0.147 *	(0.087)	0.163 **	(0.083)	-0.012	(0.089)	0.091	(0.122)	-0.202 **	(0.102)	0.080	(0.079)	0.020	(0.085)	-0.081	(0.113)
COMPAT	0.035	(0.082)	-0.008	(0.079)	0.043	(0.085)	0.198 *	(0.115)	-0.065	(0.097)	-0.122	(0.074)	0.155 *	(0.080)	0.039	(0.111)
FIN	0.083	(0.087)	-0.006	(0.084)	0.011	(0.090)	-0.096	(0.125)	-0.252 **	(0.101)	-0.146 *	(0.080)	-0.011	(0.086)	-0.131	(0.117)
ORGAN	-0.054	(0.079)	-0.015	(0.075)	0.005	(0.081)	0.039	(0.111)	-0.070	(0.093)	-0.113	(0.072)	0.078	(0.076)	-0.003	(0.105)
ENERGY_PRICE	-0.037	(0.079)	0.104	(0.076)	-0.051	(0.080)	0.142	(0.110)	0.107	(0.095)	0.036	(0.071)	0.017	(0.077)	0.015	(0.103)
PUBLIC_REGUL	-0.015	(0.078)	0.113	(0.072)	0.019	(0.079)	0.113	(0.105)	0.126	(0.094)	0.129 *	(0.069)	0.007	(0.073)	-0.003	(0.097)
PUBLIC_INCENT	0.022	(0.077)	-0.098	(0.072)	0.073	(0.078)	-0.048	(0.105)	0.012	(0.093)	-0.048	(0.068)	0.127 *	(0.073)	0.031	(0.099)
OTHER	0.079	(0.080)	0.159 **	(0.077)	-0.187 **	(0.084)	-0.073	(0.116)	-0.080	(0.093)	0.233 ***	(0.073)	-0.262 ***	(0.079)	0.138	(0.111)
IPC	-0.076	(0.080)	-0.000	(0.076)	-0.084	(0.083)	-0.114	(0.109)	0.126	(0.096)	0.092	(0.072)	0.010	(0.076)	0.203 *	(0.108)
INPC	-0.073	(0.087)	-0.046	(0.082)	0.116	(0.089)	0.194	(0.123)	-0.124	(0.104)	0.128 *	(0.078)	0.097	(0.083)	0.192 *	(0.113)
IND1	0.365	(0.576)	0.039	(0.469)	-0.528	(0.509)	0.243	(0.712)	-0.317	(0.556)	-0.146	(0.430)	-0.219	(0.444)	0.076	(0.644)
IND2	0.499	(0.394)	0.258	(0.295)	-0.118	(0.437)	-0.160	(0.549)	-0.494	(0.398)	0.007	(0.281)	-0.280	(0.299)	0.036	(0.390)
IND3	0.939 **	(0.446)	0.243	(0.357)	-0.179	(0.468)	0.377	(0.615)	0.158	(0.420)	-0.171	(0.321)	-0.037	(0.347)	0.088	(0.489)
IND4	0.380	(0.630)	0.231	(0.541)	-0.535	(0.458)	0.587	(0.581)	-0.605	(0.554)	0.144	(0.427)	-0.727	(0.621)	0.745	(0.895)
IND5	0.939	(0.616)	0.110	(0.528)	-0.455	(0.408)	0.661	(0.511)	-0.283	(0.515)	0.210	(0.401)	-0.482	(0.486)	0.573	(0.714)
IND6	1.037 **	(0.525)	0.056	(0.450)	0.140	(0.443)	0.454	(0.560)	-0.117	(0.437)	-0.122	(0.336)	-0.168	(0.473)	0.325	(0.693)
IND7	0.856	(0.628)	0.221	(0.540)	-0.715 *	(0.430)	0.255	(0.561)	-0.871	(0.535)	-0.179	(0.412)	-0.884 *	(0.519)	0.341	(0.746)
INTER_MACHINE	-1.936	(1.878)	-0.345	(1.587)												

INTRA_MACHINE	1.696 ***	(0.553)	1.516 ***	(0.510)												
INTER_TRANSPORT					-6.937 ***	(1.060)	0.506	(1.431)								
INTRA_TRANSPORT					1.032 *	(0.567)	2.870 ***	(0.717)								
INTER_BUILDING									-2.494	(1.891)	-0.804	(1.478)				
INTRA_BUILDING									0.330	(0.457)	1.118 ***	(0.340)				
INTER_ENERGY													-5.581 ***	(1.342)	0.768	(1.888)
INTRA_ENERGY													2.215 ***	(0.812)	0.630	(1.076)
Const.	-2.668	(1.799)	-5.654 ***	(1.612)	1.158	(1.409)	-7.133 ***	(1.879)	0.597	(1.726)	-6.232 ***	(1.274)	2.432 **	(1.177)	-6.609 ***	(1.569)
No. of obs. (total)	1219				1219				1219				1219			
Pseudo-R2	0.084				0.120				0.087				0.126			
LR chi2	220.1				255.5				213.9				289.4			
p-Value	0.000				0.000				0.000				0.000			

Notes: See table 1a and 1b for the definition of the variables; (*): these dependent variables are similarly constructed as the variables in table 6 but *without the non-adopting firms*; base group: firms with 1 or 2 technology applications for MACHINE_N_0; firms with only 1 technology application for TRASPORT_N_0; BUILDING_N_0; and ENERG_N_0. Due to technical reasons the dummy variables ENEXP_0 and INVEST_0 were dropped. ***, **, * denote statistical significance at the 1%, 5% and 10% test level.

Appendix:

Table A.1: Composition of data set by industry and size class

	Number of firms	Percentage of firms (%)	Percentage of firms with energy-saving technologies by industry; size class(*)
Industry (NACE classification):			
Food, beverage, tobacco (15, 16)	98	4.2	72.4
Textiles (17)	24	1.0	66.7
Clothing, leather (18, 19)	10	0.4	40.0
Wood processing (20)	37	1.6	51.4
Paper (21)	25	1.1	68.0
Printing (22)	68	2.9	52.9
Chemicals (23, 24)	85	3.7	61.2
Plastics, rubber (25)	52	2.3	63.5
Glass, stone, clay (26)	41	1.8	68.3
Metal (27)	31	1.3	54.8
Metal working (28)	167	7.2	47.9
Machinery (29)	194	8.4	60.3
Electrical machinery (31)	58	2.5	56.9
Electronics, instruments (30, 32, 331-334)	126	5.5	50.0
Vehicles (34, 35)	40	1.7	35.0
Watches (335)	22	1.0	63.6
Other manufacturing (36, 37)	37	1.6	51.4
Energy, water (40, 41)	49	2.1	75.5
Construction (45)	203	8.8	47.3
Wholesale trade (50. 51)	172	7.5	47.1
Retail trade (52)	149	6.5	47.0
Hotels, catering (55)	105	4.6	57.1
Transport, telecommunication (60-63)	142	6.2	61.3
Telecommunication (64)	11	5.6	63.6
Banks, insurance (65-67)	129	0.8	45.7
Real estate, leasing (70, 71)	18	2.2	55.6
Computer services (72, 73)	50	6.5	44.0
Business services (74)	149	0.6	38.9
Personal services (93)	14	0.5	78.6
Firm size:			
Small (less than 50 employees)	1114	48.3	40.2
Medium-sized (50-249 employees)	838	36.3	60.6
Large (250 employees and more)	354	15.4	77.7
Total	2324	100	53.5

(*): at least 1 technology application.

Table A.2: Descriptive statistics

Variable	N	Mean	Std. Dev.
LN_EMPL	2324	4.027	1.475
LN_INVEST/L	2324	8.877	1.927
INVEST/L_0	2324	0.027	0.161
HQUAL	2324	21.721	20.528
LN_ENEXP	2324	0.632	1.099
ENEXP_0	2324	0.037	0.190
R&D	2314	0.309	0.462
FOREIGN	2312	0.143	0.350
EXPORT	2316	0.475	0.500
ENV_AWARE	2324	3.219	1.042
DEMAND_EXPECT	2324	3.575	0.829
INFO	2324	0.000	1.000
COMPAT	2324	0.000	1.000
FIN	2324	0.000	1.000
ORGAN	2324	0.000	1.000
IPC	2324	3.871	0.976
INPC	2324	3.220	0.909
ENERGY_PRICE	1294	0.000	1.000
PUBLIC_REGUL	1294	0.000	1.000
PUBLIC_INCENT	1294	0.000	1.000
OTHER	1294	0.000	1.000
INTER_MACHINE	2324	0.389	0.087
INTRA_MACHINE	2324	2.452	0.263
INTER_TRANSPORT	2324	0.180	0.097
INTRA_TRANSPORT	2324	1.565	0.207
INTER_BUIDING	2324	0.446	0.078
INTRA_BUIDING	2324	2.984	0.258
INTER_ENERGIE	2324	0.210	0.100
INTRA_ENERGIE	2324	1.452	0.151

Table A.3a: Correlation matrix; basic model

	LN_EMPL	LN_INVEST/L	INVEST/L_0	HQUAL	LN_ENEXP	ENEXP_0	R&D	FOREIGN	EXPORT	ENV_AWARE	DEMAND_EXPECT	INFO	COMPAT	FIN	ORGAN	IPC	INPC	INTER_MACHINE	INTRA_MACHINE	INTER_TRANSPORT	INTRA_TRANSPORT	INTER_BUILDING	INTRA_BUILDING	INTER_ENERGY	INTRA_ENERGY
LN_EMPL	1.000																								
LN_INVEST/L	0.205	1.000																							
INVEST/L_0	-0.118	-0.761	1.000																						
HQUAL	0.041	-0.031	0.033	1.000																					
LN_ENEXP	-0.108	0.066	0.027	-0.149	1.000																				
ENEXP_0	0.052	-0.054	0.039	0.123	-0.114	1.000																			
R&D	0.253	0.113	-0.061	0.165	-0.050	-0.032	1.000																		
FOREIGN	0.169	-0.006	-0.005	0.158	-0.102	0.068	0.121	1.000																	
EXPORT	0.218	0.087	-0.040	0.143	-0.091	0.032	0.469	0.195	1.000																
ENV_AWARE	0.076	0.071	-0.015	-0.039	0.148	-0.075	0.037	-0.013	-0.039	1.000															
DEMAND_EXPECT	0.168	0.178	-0.121	0.039	-0.103	-0.004	0.130	0.061	0.150	0.033	1.000														
INFO	0.145	0.103	-0.060	-0.052	0.066	-0.050	0.028	-0.050	-0.018	0.142	0.073	1.000													
COMPAT	-0.109	-0.064	0.019	0.009	-0.031	0.010	-0.029	-0.042	0.009	-0.074	0.005	-0.004	1.000												
FIN	0.025	0.006	0.004	-0.134	0.094	-0.084	0.068	0.020	0.033	0.043	-0.043	0.006	0.003	1.000											
ORGAN	-0.049	0.008	-0.022	-0.035	0.025	-0.047	-0.008	-0.027	-0.006	-0.017	-0.025	-0.001	-0.003	0.001	1.000										
IPC	0.091	-0.007	-0.047	-0.033	-0.074	0.002	-0.006	0.037	-0.004	-0.020	0.018	0.016	0.071	0.099	-0.023	1.000									
INPC	0.072	0.045	-0.043	0.119	-0.122	-0.007	0.103	0.045	0.103	-0.006	0.026	0.012	0.007	-0.006	-0.011	0.055	1.000								
INTER_MACHINE	0.088	0.132	-0.028	-0.056	0.148	-0.089	0.333	0.032	0.304	0.079	0.021	0.022	-0.037	0.120	0.004	-0.063	-0.009	1.000							
INTRA_MACHINE	0.016	0.073	-0.008	-0.327	0.244	-0.125	0.038	-0.066	-0.035	0.077	-0.027	0.055	-0.009	0.135	0.022	0.027	-0.136	0.455	1.000						
INTER_TRANSPORT	0.020	0.131	-0.013	-0.101	0.215	0.009	-0.186	-0.101	-0.219	0.043	-0.045	0.074	-0.038	-0.043	-0.027	-0.094	-0.113	-0.121	0.207	1.000					
INTRA_TRANSPORT	-0.028	-0.004	-0.006	-0.119	0.087	0.015	-0.190	-0.090	-0.210	0.019	-0.128	0.037	-0.040	0.021	0.013	0.019	-0.001	-0.037	0.286	0.309	1.000				
INTER_BUILDING	0.081	0.143	-0.015	-0.186	0.211	-0.084	0.176	0.002	0.148	0.086	0.007	0.046	-0.065	0.120	0.003	-0.070	-0.020	0.810	0.631	-0.001	0.211	1.000			
INTRA_BUILDING	0.046	0.061	0.034	-0.004	0.016	0.027	-0.049	0.003	-0.073	0.057	-0.042	0.020	-0.072	-0.053	-0.014	-0.102	0.094	0.116	0.019	-0.112	-0.068	0.317	1.000		
INTER_ENERGY	0.094	0.155	-0.014	-0.087	0.195	-0.058	0.174	-0.023	0.135	0.092	-0.002	0.047	-0.066	0.071	-0.010	-0.084	-0.025	0.851	0.504	0.006	-0.011	0.895	0.433	1.000	
INTRA_ENERGY	0.029	0.091	-0.008	0.044	0.176	0.063	-0.233	-0.106	-0.334	0.024	-0.092	0.069	-0.084	-0.113	-0.073	-0.058	-0.088	-0.090	0.168	0.591	0.319	0.161	0.165	0.231	1.000

Note: The correlation coefficients are larger than 0.04 are statistically significant at the 10% test-level.

Table 3b: Correlation matrix; model with motive variables

	LN_EMPL	LN_INVEST/L	INVEST/L_0	HQUAL	LN_ENEXP	ENEXP_0	R&D	FOREIGN	EXPORT	ENV_AWARE	DEMAND_EXPECT	INFO	COMPAT	FIN	ORGAN	IPC	INPC	INTER_MACHINE	INTRA_MACHINE	INTER_TRANSPORT	INTRA_TRANSPORT	INTER_BUILDING	INTRA_BUILDING	INTER_ENERGY	INTRA_ENERGY	ENERGY_PRICE	PUBLIC_REGUL	PUBLIC_INCENT	OTHER
LN_EMPL	1.000																												
LN_INVEST/L	0.171	1.000																											
INVEST/L_0	-0.076	-0.631	1.000																										
HQUAL	0.077	-0.033	0.078	1.000																									
LN_ENEXP	-0.097	0.153	-0.041	-0.170	1.000																								
ENEXP_0	0.061	-0.029	0.029	0.039	-0.098	1.000																							
R&D	0.226	0.108	-0.070	0.185	-0.060	-0.043	1.000																						
FOREIGN	0.139	-0.025	0.016	0.152	-0.097	0.046	0.109	1.000																					
EXPORT	0.209	0.089	-0.053	0.157	-0.115	0.008	0.495	0.206	1.000																				
ENV_AWARE	0.051	0.034	0.027	-0.013	0.136	-0.015	0.001	-0.006	-0.024	1.000																			
DEMAND_EXPECT	0.125	0.162	-0.092	0.036	-0.104	-0.015	0.094	0.062	0.140	0.064	1.000																		
INFO	0.084	0.069	-0.056	-0.010	0.045	0.001	0.001	-0.045	-0.050	0.071	0.046	1.000																	
COMPAT	-0.065	-0.077	0.041	-0.020	-0.014	-0.004	-0.011	-0.047	0.031	-0.010	-0.001	0.120	1.000																
FIN	-0.045	-0.063	0.014	-0.100	0.056	-0.070	0.053	0.067	0.032	-0.022	-0.053	-0.174	0.102	1.000															
ORGAN	-0.080	-0.003	-0.027	-0.045	-0.013	-0.054	-0.001	-0.023	-0.007	-0.084	-0.035	-0.038	0.064	-0.097	1.000														
IPC	0.051	-0.072	0.010	-0.005	-0.068	0.024	-0.015	0.026	0.024	-0.026	-0.027	0.003	0.075	0.086	-0.042	1.000													
INPC	0.023	0.005	0.017	0.120	-0.135	-0.029	0.072	0.024	0.092	0.025	0.017	0.009	0.010	-0.030	-0.020	0.081	1.000												
INTER_MACHINE	0.081	0.179	-0.062	-0.039	0.187	-0.090	0.351	0.074	0.305	0.055	-0.014	-0.017	-0.003	0.087	0.003	-0.070	-0.006	1.000											
INTRA_MACHINE	0.029	0.098	-0.055	-0.291	0.264	-0.083	0.063	-0.038	-0.025	0.060	-0.033	0.007	0.064	0.076	-0.008	0.003	-0.139	0.493	1.000										
INTER_TRANSPORT	0.004	0.208	-0.036	-0.111	0.275	0.007	-0.221	-0.150	-0.285	0.083	-0.050	0.077	-0.038	-0.103	-0.042	-0.142	-0.125	-0.081	0.207	1.000									
INTRA_TRANSPORT	-0.037	-0.018	-0.014	-0.158	0.104	-0.012	-0.165	-0.111	-0.222	0.023	-0.147	0.037	-0.005	0.010	-0.001	0.044	0.008	-0.018	0.322	0.265	1.000								
INTER_BUILDING	0.092	0.196	-0.056	-0.165	0.247	-0.072	0.186	0.027	0.142	0.071	-0.026	0.008	-0.020	0.067	-0.013	-0.083	-0.017	0.834	0.648	0.038	0.198	1.000							
INTRA_BUILDING	0.095	0.089	0.066	0.005	0.041	0.043	-0.034	-0.025	-0.077	0.073	-0.034	0.072	-0.089	-0.051	-0.023	-0.120	0.120	0.191	0.050	-0.032	-0.100	0.365	1.000						
INTER_ENERGY	0.101	0.219	-0.048	-0.072	0.241	-0.050	0.177	-0.004	0.124	0.093	-0.032	0.028	-0.037	0.026	-0.023	-0.096	-0.019	0.862	0.534	0.080	-0.017	0.905	0.488	1.000					
INTRA_ENERGY	0.033	0.166	-0.020	0.026	0.253	0.035	-0.246	-0.135	-0.360	0.059	-0.096	0.088	-0.102	-0.161	-0.085	-0.078	-0.090	-0.008	0.218	0.644	0.264	0.234	0.218	0.321	1.000				
ENERGY_PRICE	0.015	-0.016	-0.018	-0.056	-0.014	-0.055	0.033	-0.018	0.030	-0.011	0.093	0.215	0.115	0.113	0.115	0.048	0.023	0.046	0.049	-0.039	0.058	0.053	-0.051	0.018	-0.079	1.000			
PUBLIC_REGUL	0.147	0.052	-0.018	0.032	0.044	-0.003	0.004	-0.012	-0.008	0.053	0.002	0.139	0.058	0.027	0.046	-0.004	-0.003	-0.013	-0.009	0.037	-0.002	0.001	0.077	0.013	0.032	-0.003	1.000		
PUBLIC_INCENT	0.003	-0.005	-0.006	-0.002	0.071	-0.008	-0.037	-0.016	-0.032	0.050	-0.051	0.146	0.012	0.019	0.104	-0.057	-0.056	0.029	0.036	0.060	0.052	0.030	0.016	0.039	0.051	-0.004	0.004	1.000	
OTHER	0.022	0.026	0.016	0.012	0.025	-0.015	0.008	-0.057	-0.040	0.304	0.064	0.128	-0.009	-0.010	-0.051	0.036	0.044	-0.007	-0.006	0.024	-0.009	0.011	0.068	0.037	0.060	0.005	0.016	-0.004	1.000

Note: The correlation coefficients larger than 0.04 are statistically significant at the 10% test-level.

Table A.4: Principal components factor analysis of *barriers* of technology adoption (rotated factor pattern; factor loadings)

Obstacles	*Factor 1*	*Factor 2*	*Factor 3*	*Factor 4*
Anticipated falling price trend makes adoption currently unattractive	**0.27**	-0.00	-0.06	0.00
Technology not mature enough	**0.41**	-0.14	-0.08	-0.04
Information problems / costs	**0.29**	-0.13	-0.05	-0.01
Performance of technology still uncertain	**0.37**	-0.13	0.05	0.01
Technology too expensive	0.14	**0.47**	-0.14	-0.07
Too large investment volume	-0.13	**0.39**	-0.10	0.00
Too long payback period	-0.06	**0.37**	-0.11	0.01
Lack of liquidity	-0.22	**0.22**	-0.05	0.02
Inadequate know-how	-0.08	-0.10	**0.41**	-0.02
Lack of specialized personnel	-0.07	-0.10	**0.40**	-0.02
Management thoroughly absorbed by other tasks	-0.08	-0.05	**0.36**	-0.02
Uncertainty with respect to public regulation	0.05	0.03	**0.12**	0.02
Lack of compatibility with current product programme	-0.04	-0.01	-0.03	**0.53**
Lack of compatibility with current production technology	-0.04	0.01	-0.05	**0.53**
Statistics				
Number of observations	2324			
Kaiser's measure of sampling adequacy (MSA)	0.860			
Root mean square off-diagonal residuals (RMSE)	0.052			
Variance explained by each factor	2.811	2.576	2.722	1.834
Final communality estimate	9.943			
Characterization of the four factors based on the factor pattern:				
Factor 1: INFO				
Factor 2: FIN				
Factor 3: ORGAN				
Factor 4: COMPAT				

Note: The original 14 variables were measured on a five-point Likert-scale. The four-factor solution was chosen according to statistical criteria that are implemented in the software we used (SAS). In addition, we took a look whether these results made a sense in economic terms.

Table A.5: Principal components factor analysis of *motives* of technology adoption (rotated factor pattern; factor loadings)

Obstacles	*Factor 1*	*Factor 2*	*Factor 3*	*Factor 4*
Too high / increasing energy prices	**0.43**	-0.03	-0.14	-0.04
Current energy taxes	**0.42**	-0.12	-0.03	-0.03
Expected energy taxes	**0.41**	-0.05	-0.04	-0.04
Uncertainty as to future energy bottle-necks	0.16	**0.21**	0.06	-0.13
Current or expected demand for environment-friendly products	-0.08	**0.66**	-0.22	-0.01
Protection of environment	-0.08	**0.47**	0.10	-0.14
Public incentives for CO_2 reduction	-0.07	-0.09	**0.61**	-0.15
Public promotion of energy efficiency	-0.13	-0.08	**0.61**	-0.14
Compliance to current public regulation	-0.05	-0.13	-0.16	**0.57**
Compliance to expected new public regulation	-0.05	-0.08	-0.12	**0.53**
Compliance to agreements with government agencies	-0.12	**0.22**	-0.09	**0.30**
Statistics				
Number of observations	1294			
Kaiser's measure of sampling adequacy (MSA)	0.830			
Root mean square off-diagonal residuals (RMSE)	0.072			
Variance explained by each factor	2.258	2.073	1.878	1.633
Final communality estimate	7.840			
Characterization of the four factors based on the factor pattern:				
Factor 1: Energy prices, taxes(ENERGY_PRICE)				
Factor 2: (OTHER)				
Factor 3: Public incentives (PUBLIC_INCENT)				
Factor 4: Compliance to public regulation (PUBLIC_REGUL)				

Note: The original 11 variables were measured on a five-point Likert-scale. The four-factor solution was chosen according to statistical criteria that are implemented in the software we used (SAS). In addition, we took a look whether these results made a sense in economic terms.

Table A.6: Probit estimates of the adoption of several types of energy-saving technologies; marginal effects

	MACHINE		TRANSPORT		BUILDING		ENERGY	
LN_EMPL	0.056 ***	(0.007)	0.036 ***	(0.005)	0.078 ***	(0.007)	0.051 ***	(0.006)
LN_INVEST/L	0.029 ***	(0.008)	0.012 *	(0.007)	0.031 ***	(0.008)	0.048 ***	(0.007)
INVEST/L_0	0.134	(0.097)	-0.039	(0.094)	0.142	(0.096)	0.345 ***	(0.092)
HQUAL	-0.000	(0.001)	-0.001	(0.000)	-0.001	(0.001)	-0.001 *	(0.000)
LN_ENEXP	0.010	(0.009)	-0.003	(0.007)	-0.008	(0.009)	0.016 **	(0.008)
ENEXP_0	-0.148 ***	(0.055)	-0.094 *	(0.048)	-0.092 *	(0.051)	-0.067	(0.049)
R\&D	0.136 ***	(0.023)	0.043 **	(0.020)	0.087 ***	(0.024)	0.070 ***	(0.019)
FOREIGN	0.004	(0.027)	-0.038	(0.023)	-0.066 **	(0.027)	-0.053 **	(0.023)
EXPORT	-0.004	(0.023)	-0.027	(0.019)	0.003	(0.023)	0.005	(0.020)
ENV_AWARE	0.070 ***	(0.009)	0.035 ***	(0.008)	0.057 ***	(0.009)	0.037 ***	(0.008)
DEMAND_EXPECT	0.016	(0.012)	0.002	(0.010)	0.033 ***	(0.011)	0.014	(0.010)
INFO	0.047 ***	(0.009)	0.032 ***	(0.008)	0.072 ***	(0.009)	0.021 ***	(0.008)
COMPAT	-0.075 ***	(0.009)	-0.029 ***	(0.008)	-0.079 ***	(0.009)	-0.049 ***	(0.008)
FIN	0.066 ***	(0.009)	0.031 ***	(0.008)	0.089 ***	(0.009)	0.032 ***	(0.008)
ORGAN	0.012	(0.009)	0.003	(0.008)	0.004	(0.009)	-0.006	(0.008)
IPC	0.026 ***	(0.010)	0.012	(0.008)	0.013	(0.010)	0.016 *	(0.008)
INPC	0.009	(0.010)	-0.004	(0.009)	0.013	(0.010)	-0.002	(0.009)
IND1	-0.019	(0.063)	0.034	(0.048)	-0.014	(0.058)	0.025	(0.048)
IND2	-0.015	(0.043)	0.023	(0.040)	0.016	(0.040)	0.031	(0.033)
IND3	-0.025	(0.049)	0.046	(0.043)	0.002	(0.045)	0.032	(0.038)
IND4	0.035	(0.070)	0.058	(0.042)	0.062	(0.056)	0.137 **	(0.065)
IND5	0.014	(0.069)	0.063 *	(0.037)	0.063	(0.053)	0.103 **	(0.052)
IND6	-0.002	(0.059)	0.005	(0.039)	0.042	(0.046)	0.066	(0.051)
IND7	0.031	(0.070)	0.068 *	(0.039)	0.084	(0.055)	0.131 **	(0.056)
INTER_MACHINE	0.533 **	(0.213)						
INTRA_MACHINE	-0.030	(0.066)						
INTER_TRANSPORT			0.768 ***	(0.094)				
INTRA_TRANSPORT			0.032	(0.051)				
INTER_BUIDING					0.548 ***	(0.197)		
INTRA_BUIDING					-0.006	(0.045)		
INTER_ENERGIE							0.759 ***	(0.142)
INTRA_ENERGIE							-0.212 **	(0.086)
No. of obs.	2285		2285		2285		2285	
Pseudo-R2	0.183		0.149		0.209		0.215	
LR chi2	560.2		323.3		656.7		515.0	
p-Value	0.000		0.000		0.000		0.000	

Notes: See table 1a and 1b for the definition of the variables. ***, **, * denote statistical significance at the 1%, 5% and 10% test level.

Table A.7: Intra-firm adoption of several types of energy-saving technologies; ordered probit estimates (3 levels)

	MACHINE_N		TRANSPORT_N		BUILDING_N		ENERGY_N	
LN_EMPL	0.187 ***	(0.020)	0.159 ***	(0.023)	0.256 ***	(0.021)	0.220 ***	(0.023)
LN_INVEST/L	0.075 ***	(0.023)	0.050 *	(0.028)	0.114 ***	(0.023)	0.202 ***	(0.029)
INVEST/L_0	0.200	(0.295)	-0.174	(0.407)	0.757 ***	(0.289)	1.368 ***	(0.395)
HQUAL	-0.000	(0.002)	-0.002	(0.002)	-0.002	(0.002)	-0.003	(0.002)
LN_ENEXP	0.039	(0.027)	-0.014	(0.032)	-0.020	(0.027)	0.079 **	(0.032)
ENEXP_0	-0.433 ***	(0.168)	-0.508 **	(0.213)	-0.234	(0.155)	-0.350 *	(0.206)
R\&D	0.391 ***	(0.069)	0.216 **	(0.085)	0.273 ***	(0.070)	0.279 ***	(0.079)
FOREIGN	-0.044	(0.078)	-0.163	(0.100)	-0.237 ***	(0.080)	-0.284 ***	(0.095)
EXPORT	0.011	(0.068)	-0.125	(0.082)	0.005	(0.068)	0.032	(0.083)
ENV_AWARE	0.220 ***	(0.027)	0.161 ***	(0.033)	0.197 ***	(0.027)	0.169 ***	(0.033)
DEMAND_EXPECT	0.042	(0.034)	0.009	(0.041)	0.094 ***	(0.034)	0.051	(0.041)
INFO	0.157 ***	(0.028)	0.146 ***	(0.034)	0.228 ***	(0.028)	0.073 **	(0.033)
COMPAT	-0.206 ***	(0.028)	-0.103 ***	(0.034)	-0.240 ***	(0.028)	-0.191 ***	(0.033)
FIN	0.181 ***	(0.028)	0.128 ***	(0.035)	0.235 ***	(0.029)	0.116 ***	(0.034)
ORGAN	0.040	(0.027)	0.018	(0.033)	-0.000	(0.027)	-0.018	(0.032)
IPC	0.067 **	(0.028)	0.047	(0.034)	0.053 *	(0.028)	0.080 **	(0.034)
INPC	0.020	(0.031)	-0.007	(0.037)	0.056 *	(0.031)	0.010	(0.036)
IND1	-0.032	(0.183)	0.170	(0.205)	-0.080	(0.170)	0.099	(0.199)
IND2	0.009	(0.122)	0.105	(0.169)	0.032	(0.116)	0.129	(0.132)
IND3	-0.014	(0.142)	0.230	(0.184)	-0.019	(0.131)	0.155	(0.156)
IND4	0.102	(0.204)	0.297 *	(0.178)	0.202	(0.165)	0.570 **	(0.270)
IND5	0.057	(0.200)	0.322 **	(0.158)	0.203	(0.156)	0.444 **	(0.215)
IND6	0.016	(0.171)	0.088	(0.165)	0.086	(0.134)	0.283	(0.210)
IND7	0.128	(0.204)	0.309 *	(0.168)	0.194	(0.161)	0.538 **	(0.230)
INTER_MACHINE	1.316 **	(0.618)						
INTRA_MACHINE	0.160	(0.194)						
INTER_TRANSPORT			3.173 ***	(0.406)				
INTRA_TRANSPORT			0.378 *	(0.219)				
INTER_BUIDING					1.394 **	(0.583)		
INTRA_BUIDING					0.149	(0.133)		
INTER_ENERGIE							2.944 ***	(0.594)
INTRA_ENERGIE							-0.727 **	(0.349)
cut1	4.002 ***	(0.608)	4.114 ***	(0.560)	4.718 ***	(0.488)	4.662 ***	(0.492)
cut2	4.812 ***	(0.610)	4.736 ***	(0.562)	5.375 ***	(0.490)	5.465 ***	(0.496)
No. of obs.	2285		2285		2285		2285	
Pseudo-R2	0.139		0.123		0.160		0.174	
LR chi2	597.4		337.2		724.8		528.3	
p-Value	0.000		0.000		0.000		0.000	

Notes: See table 1a and 1b for the definition of the variables. ***, **, * denote statistical significance at the 1%, 5% and 10% test level.

Table A.8: Intra-firm adoption of several types of energy-saving technologies; ordered probit estimates (6 levels)

	MACHINE_N_5		TRANSPORT_N_3		BUILDING_N_5		ENERGY_N_4	
LN_EMPL	0.183 ***	(0.019)	0.155 ***	(0.023)	0.257 ***	(0.020)	0.222 ***	(0.023)
LN_INVEST/L	0.077 ***	(0.022)	0.051 *	(0.028)	0.129 ***	(0.022)	0.200 ***	(0.028)
INVEST/L_0	0.216	(0.288)	-0.128	(0.399)	0.866 ***	(0.279)	1.339 ***	(0.392)
HQUAL	-0.000	(0.002)	-0.003	(0.002)	-0.002	(0.002)	-0.003	(0.002)
LN_ENEXP	0.049 *	(0.026)	-0.008	(0.031)	-0.008	(0.025)	0.081 ***	(0.031)
ENEXP_0	-0.419 **	(0.164)	-0.492 **	(0.212)	-0.256 *	(0.149)	-0.363 *	(0.205)
R\&D	0.350 ***	(0.066)	0.214 **	(0.083)	0.231 ***	(0.066)	0.250 ***	(0.077)
FOREIGN	-0.097	(0.075)	-0.173 *	(0.099)	-0.245 ***	(0.076)	-0.259 ***	(0.094)
EXPORT	0.021	(0.066)	-0.118	(0.081)	0.018	(0.065)	0.023	(0.082)
ENV_AWARE	0.228 ***	(0.026)	0.159 ***	(0.032)	0.196 ***	(0.026)	0.167 ***	(0.032)
DEMAND_EXPECT	0.041	(0.033)	-0.004	(0.041)	0.082 **	(0.032)	0.053	(0.040)
INFO	0.162 ***	(0.027)	0.139 ***	(0.034)	0.227 ***	(0.027)	0.079 **	(0.033)
COMPAT	-0.188 ***	(0.027)	-0.098 ***	(0.033)	-0.222 ***	(0.027)	-0.178 ***	(0.032)
FIN	0.175 ***	(0.028)	0.119 ***	(0.034)	0.215 ***	(0.027)	0.120 ***	(0.034)
ORGAN	0.036	(0.026)	0.015	(0.032)	0.010	(0.026)	-0.027	(0.032)
IPC	0.059 **	(0.027)	0.042	(0.033)	0.052 *	(0.027)	0.080 **	(0.033)
INPC	0.034	(0.030)	0.002	(0.036)	0.055 *	(0.029)	0.003	(0.035)
IND1	-0.077	(0.175)	0.161	(0.203)	-0.068	(0.161)	0.091	(0.197)
IND2	-0.054	(0.116)	0.107	(0.166)	0.025	(0.109)	0.140	(0.130)
IND3	-0.051	(0.135)	0.210	(0.182)	0.038	(0.124)	0.158	(0.154)
IND4	0.075	(0.196)	0.275	(0.176)	0.195	(0.157)	0.519 *	(0.267)
IND5	0.026	(0.192)	0.277 *	(0.155)	0.213	(0.149)	0.405 *	(0.213)
IND6	-0.019	(0.165)	0.023	(0.163)	0.123	(0.127)	0.254	(0.208)
IND7	0.046	(0.196)	0.299 *	(0.166)	0.207	(0.153)	0.488 **	(0.227)
INTER_MACHINE	1.079 *	(0.591)						
INTRA_MACHINE	0.167	(0.185)						
INTER_TRANSPORT			3.053 ***	(0.403)				
INTRA_TRANSPORT			0.406 *	(0.216)				
INTER_BUIDING					1.220 **	(0.557)		
INTRA_BUIDING					0.161	(0.126)		
INTER_ENERGIE							2.758 ***	(0.586)
INTRA_ENERGIE							-0.541	(0.342)
cut1	3.911 ***	(0.580)	4.062 ***	(0.552)	4.791 ***	(0.460)	4.823 ***	(0.480)
cut2	4.284 ***	(0.581)	4.684 ***	(0.554)	5.066 ***	(0.461)	5.625 ***	(0.484)
cut3	4.724 ***	(0.583)	5.158 ***	(0.557)	5.448 ***	(0.462)	6.509 ***	(0.494)
cut4	5.208 ***	(0.584)			5.839 ***	(0.464)	7.050 ***	(0.507)
cut5	5.749 ***	(0.586)			6.219 ***	(0.466)		
No. of obs.	2285		2285		2285		2285	
Pseudo-R2	0.103		0.109		0.119		0.164	
LR chi2	602.1		324.2		763.4		536.6	
p-Value	0.000		0.000		0.000		0.000	

Notes: See table 1a and 1b for the definition of the variables. ***, **, * denote statistical significance at the 1%, 5% and 10% test level.