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Energy Conservation and Investment Behaviour: an empirical analysis of influential factors and attitudes

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ENERGY CONSERVATION AND INVESTMENT BEHAVIOUR: AN EMPIRICAL ANALYSIS OF INFLUENTIAL FACTORS AND ATTITUDES

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1. Introduction

Energy conservation as part of an integrated environmental plan has had much attention, in The Netherlands and elsewhere in the world. Two main reasons explain this interest. The first reason it that it has become clear that the emissions of CO_2 must be reduced and eventually stabilized. The goals set by the Dutch government require a stabilization of the emission level of the level of 1989 (Dutch National Environmental policy plan (1990), Nota Energiebesparing (1990), Vervolgnota Energiebesparing (1993)). Energy conservation is regarded as one of the main means of reducing CO_2 emissions, and it has been shown that the cost of reducing energy demand by the implementation of more energy efficient technologies is reasonably low: given the state of technology and current energy prices a reduction in energy consumption of over 20% can be realized at negative costs (Blok *et al.* (1990, 1992); SEO (1991); Van der Werff and Opschoor (1992)).

The second reason why energy conservation is of interest (to especially economists) is that a great part of the economically profitable energy conservation technologies is not implemented by industry (Van der Werff and Opschoor 1992). The general theoretical thought is that firms are somehow hampered in implementing energy efficient technologies. Market barriers are named as an explanation why firm do not implement all economically attractive technologies. Other reasons include: a small incentive for investing in energy conservation technologies, bounded rationality and paradigm theory.

An empirical analysis of barriers for the adoption of energy conservation technologies *at the firm level* has not often been performed. In this paper we try to investigate empirically the relations between firm specific variables and the energy conservation investment decision, in order to make a preliminary ranking in the importance of some decision and control variables on the actual observed investment decision. Consequently, the empirically established relations can be checked against the existing list of theoretical barriers. Our paper explores the influences of some variables on the energy conservation investment decision, rather than explaining the decision process by a general model. We use data that were collected during a survey on energy conservation investment behaviour in the Netherlands in 1993.

In section 2 we briefly sketch an investment framework and give a list of potentially important variables and barriers, which are often mentioned in literature. The survey will be discussed in section 3, as well as the definition of investment behaviour. We will also describe the method of analysis. In section 4 the empirical influences of variables on the observed investment decision are analyzed. The result of the analysis will be a clustering of potentially important variables into important and unimportant variables. Section 5 analyses statements and attitudes about the importance of variables in future investment decisions. The result here will also be a clustering of variables according to their empirical importance. Section 6 combines the results of sections 4 and 5, and draws conclusions from the combined result. Knowing which factors can be demonstrated to be important is a necessary step before one can actually start building a comprehensible model.

2. A sketch on investment decisions and barriers to energy conservation

In a textbook world, where there is no uncertainty about future states of events and cashflows, all information is freely available at no costs and there is a unlimited access to capital market, the investment decision of a profit (or utility) maximizing firm would imply investing in all available investment alternatives that have a positive net present value (cf. Bierman and Smidt 1993; Brealey and Myers, 1991). In this situation the (certain) cashflows and hence profitability of an energy conservation technology is determined by energy prices alone.[1]

Introducing uncertainty and interdependence between alternatives result in the first reasons why firms do not invest in seemingly profitable technologies: 1) the risks attached to investment are too high; and 2) the impact on other technologies are negative that they offset the possible gains. The obvious variable determining energy conservation gains is the energy price. Expectations regarding future energy prices and expected fluctuations in future energy prices are the main economic source of uncertainty connected with energy conservation investments. In other words: high fluctuation in energy prices can be seen as a barrier to adoption of energy efficient technologies. Low energy prices lead to low expected net present values of an investment. Consequently, lower expected energy prices can be a barrier to the adoption of energy efficient technologies.

There are two ways of incorporating risk into the investment decision. The first way is to make risk explicit by introducing a probability density function of expected return. This is a very complex (but theoretically proper) way of assessing risk. The second way is more commonly used by firms: risk is implicitly assessed by requiring that the investment still is profitable after some adjustments for risk. The easiest way of adjusting is to invest only in projects with high returns on investment. In practice it means that firms require high internal rates of return, or more commonly used: a shorter pay back period. Firms that are (extremely) risk averse have short pay back periods. Theoretically this would imply a lower degree of implementation.

Many firms use a uniform criterion for evaluating investments. For many firms this would be a uniform hurdle rate for pay back periods. Some firms, however, appear to use a different hurdle rate for energy conservation technologies. A higher hurdle rate indicates that these firms attach higher risk to the energy conservation technologies. By the same argument mentioned above, one would expect that these firms have implemented less in energy conservation technologies. The opposite could be true for firms who use lower hurdle rates for energy conservation technologies.

Energy prices determine the profitability of an energy efficient technology in a sense that higher prices mean higher gains. But the energy conservation gains are also determined by the actual amount of energy saved. Apparently firms with a larger energy bill can save more energy in absolute terms than firms with a small energy bill (*ceteris paribus*). Theoretically this would imply that firms with a higher energy bill have more incentive to invest and therefore have a higher degree of implementating energy conservation technologies.

The framework of profit (or utility) maximizing firms cannot explain the energy conservation investment behaviour adequately. Simon (1955, 1959) suggests a framework of satisfycing profit (or utility). His framework of rationality is one "...that is compatible with the access to information and the computational capacities that are actually possessed by organisms, including man, in the kinds of environments in which such organisms exist (Simon 1955)". It is often referred to as "bounded rationality". Information in real situation can be costly and the costs of collecting all necessary information can offset the potential gains. Simon's observation that information is costly leads him to specify his "satisficing principle". Once a certain profit (or utility) is reached, the firm does not look for further investment projects, because the gains are too small compared to the effort and costs of information collection. This is especially true when the expected gains (in terms of money saved) are small. This holds for smaller firms. Large firms can profit from "economies of scale". Moreover, the costs of collecting information will be lower, due to a higher number of information

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[1] Implicitly we assume that investment costs and technological efficiency are fixed. Expectations about future energy prices play no role because every state of events is known in advance. As a consequence of all these assumptions, firms have the same expected rate of return as well.

lines. Size of a firm, therefore, can serve as a proxy for economies of scale effects, and is expected to have a positive influence on energy conservation decision.

The second part of a bounded rationality framework is a bounded search strategy due to technologically induced factors. Dosi (1988) argues that firms are "locked in" in a certain technological paradigm, where they are not "open minded" about innovative technologies in another paradigm. This can explain the phenomenon of the "distance to core business" argument. Firms mention the fact that energy conservation is not their core business activity and neglect to (or are not able to) fully analyze the potential gains of energy conservation, resulting in a low diffusion of technologies (see also Schot 1991).

Other theories, especially theories of firm (cf. Jensen and Meckling 1976; Williamson 1974), emphasize the importance of the organization and the position of management on the energy conservation investment behaviour. Principal-agent theories (landlord-tenant problems) are used to explain the role of management as a barrier to the adoption of energy conservation investments. DeCanio (1993) states that "managers will be deterred from initiating risky projects if the personal consequences of failure seem to be much higher than the payoff to success". Sassone and Martucci (1984) have shown that management of a firm is likely to underestimate the possible gains from *cost-cutting* technologies by 10% while they overestimate the gains of market opportunities with 40%. Cost-reducing investment are not properly valued, leading to an under investment in (among others) energy conservation technologies.

Also the costs of initiating or replacing old equipment can be an explanation of why the diffusion process of economically attractive options is going slow. In many cases a more efficient technology is already available, but firms will not replace their old equipment because it is not yet fully depreciated. Firms who do replace their old technology with a more efficient technology are expected to have a higher degree of implementation.

In connection with costs of initiating or replacing, the firm's financial situation and market expectations might play an important role. Replacement of technologies often requires the possibility of investing in a new technology. However, the situation could occur where replacement is profitable, but the firm is not capable to raise the money for the initial capital outlay, or that capital is more urgently needed in another part of the firm. Theoretically one would expect that poor market expectations and financial situation lead to postponement of replacement, and consequently to a lower degree of implementation. Market imperfections, such as limited access to capital market, lending at an interest rate which is higher than the normal interest rate may re-enforce the difficulties of raising capital. The expectation is that more possible types of financial sources would increase investments. Also the nature of the financial sources might play a role. Financing investments with own money might be more expensive, but is often easier than borrowing from the bank.

So far we have discussed some variables that are expected to have an influence on the energy conservation investment behaviour. Some of them were expected to have a positive influence, such as size, energy bill, high expected energy prices and low hurdle rates for energy conservation investments. Others were expected to have a negative influence on the investment decision, and might serve as potential barriers for the diffusion of energy conservation technologies. Among this group of variables are: low expected energy prices, large expected fluctuation in energy prices, market failures (limited access to capital market), high initial costs of information collection, non-core business activities and lack of openness to innovation. Below, we will empirically investigate the influence of all these variables on investment behaviour. However, first we will present the definition of investment behaviour which we have not yet given so far, and discuss the survey.

3. Survey, definitions and sectoral results

To analyze the importance of the variables on the energy conservation investment decision a survey was held in 1993, questioning 313 Dutch firms about their state of the art implementation and profitability of energy efficient technologies. The survey consists of two parts. The first part inventories the state of the art knowledge and implementation of technologies at the firm level. The second part consists of the registration of firm specific variables and attitudes that can, in some way, serve as an explanation for the observed state of the art implementation. Observed differences in investment behaviour can then be understood in terms of different firm specific characteristics, of which some can pose an effective barrier to the adoption of energy efficient technologies.

3.1 State of the art knowledge, implementation and profitability

Because the possibilities of energy efficiency improvement differ much across sectors, firms were questioned about technologies that are applicable to the sector in which they are economically active. The degree of disaggregation is a 2-digit sectoral code. This resulted in a selection of 41 sectors, see appendix A. The energy producing sector and the household sector are not considered in this paper. The data on conservation technologies in the 41 different (sub)sectors were taken from the database ICARUS (Blok *et al.* 1992). For each technology that can be implemented before the year 2000, ICARUS provides information on technical aspects (such as potential savings, lifetime, main fuel carrier) and some economic aspects (such as initial investment costs and operation and maintenance costs). With these data it is possible to calculate the technical and economic potential for energy savings in the year 2000 (see Blok *et al.* 1992).
In our survey each firm *i* was provided with a list of six technologically possible energy conservation technologies ($T_{i1}..T_{i6}$) and was asked which of those technologies:

- were known;
- were implemented;
- were considered profitable.

The following coding scheme was adopted:

$$X_{ij} = \begin{cases} 1, & \textit{if firm i knows option j} \\ 0, & \textit{else} \end{cases}$$

$$Y_{ij} = \begin{cases} 1, & \textit{if firm i implements option j} \\ 0, & \textit{else} \end{cases}$$

$$Z_{ij} = \begin{cases} 1, & \textit{if firm i finds option j profitable} \\ 0, & \textit{else} \end{cases}$$

From ICARUS the potential energy savings expressed as the percentage of reduced energy consumption were taken. Let the set of potential energy savings for each firm be coded as $P_{i1}..P_{i6}$. For notational convenience we do not explicitly refer to each individual technology. By construction of the database, $P_{i1}..P_{i6}$ refer to the potential savings for the six corresponding technologies that a respondent was confronted with. Having only 313 respondents in 41 (sub)sectors, statistical analysis is very difficult; therefore the respondents were grouped in 11 aggregated sector, see appendix A.

With these coding schemes we can explore the state of the art knowledge, the implementation of energy efficient technologies and the stated profitability of technologies by firms. The state of the art knowledge is the ratio of weighed known technologies over the maximum possible energy conservation technologies:

$$K_i = \frac{\sum_{j=1}^{6} P_{ij} * X_{ij}}{\sum_{j=1}^{6} P_{ij}} * 100\%$$

The state of the art implementation is defined by:

$$I_i = \frac{\sum_{j=1}^{6} P_{ij} * Y_{ij}}{\sum_{j=1}^{6} P_{ij} * X_{ij}} * 100\%$$

Here it is implicitly assumed that a firm can only implement a technology when it is known. Similarly, the state of the art profitability is defined by:

$$R_i = \frac{\sum_{j=1}^{6} P_{ij} * Z_{ij}}{\sum_{j=1}^{6} P_{ij} * X_{ij}} * 100\%$$

However, a misleading image can be created. The data show that there are many respondents who implement a certain technology although they claim it is not profitable. The opposite is also true: Some technologies are considered profitable, but are nevertheless not implemented. Implementation in the above definition includes both profitable and non-profitable technologies (I_i is independent of the Z_{ij}'s). Profitable technologies can be implemented or not. We call profitable technologies that not (yet) have been implemented *the unexploited potential*, and we call the technologies that have been implemented but were not considered profitable *non-profitable implementations.* Table 1 provides insights into the division of implemented and profitable technologies.

Sector	total knowledge (1)	total implemented (2)	non-profit implemented (3)	profitable implemented (4)	unexploited potential (5)	total profitable (6)
Agriculture	68.0	42.5	9.2	33.3	5.7	44.3
food, drinks	58.1	65.2	14.4	50.8	5.9	54.6
meat	70.3	65.1	6.3	58.8	14.2	78.3
bulk chemicals	45.3	39.5	10.8	28.6	24.3	46.2
other chemical	56.7	55.1	16.6	39.5	0.0	39.5
building	53.9	76.3	16.2	60.1	1.0	65.5
metal	29.5	76.8	14.4	62.3	5.5	68.8

other industry	67.8	61.3	19.9	41.4	11.0	49.8
banks & insurance	82.9	66.2	9.84	56.4	9.8	65.6
retail	88.3	60.5	9.2	51.4	14.1	63.6
health & education	85.9	72.0	17.8	5.4	7.9	62.7
total sample	66.4	60.8	13.1	47.8	8.4	56.5

Table 1: Summary results of implementation and profitability.

Thus, in column (1) knowledge is presented as the percentage of maximum technologically attainable energy efficiency; column (2) indicates the percentage of known technologies that is implemented (be it profitable or not); in column (3) the percentage of non-profitable energy conservation implementation is listed, whereas in (4) the profitable investments are listed. In theory, (2) should equal (3)+(4), because by definition the total implementation exists of profitable and non-profitable implementations. Column (5) shows the unexploited potential, which is defined as the percentage of known technologies that are considered profitable but not implemented for some reason. Column (4) and (5) list all the profitable technologies (implemented and not-implemented, respectively); therefore by definition column (6) should equal (4)+(5). In practice, this is not always the case, because these results are aggregates at a sectoral level. Differences imply that the respondents in this sector differ largely in implementation and profitability.

We find that there is a big difference in knowledge between sectors. Some sectors know very little about the technical possibilities of energy conservation (such as the the metal sector and the bulk chemical sector), while some sectors know almost all energy conservation technologies (such as the health and education sector and the retail sector). One possible explanation may be that the technologies in the metal industry and chemical industry are more complicated than in, for instance, the retail sector. A reason why the health and education sector know many technologies might be the close connections with the (local) government.

Total implementation of known technologies varies from about 40% bulk chemicals to almost 80% in the building and metal industry. Also the unexploited potential varies very much over sectors, while the share of non-profitable implementations is rather constant (about 17% of total implementation). From table 1 one can see that an important role is played by column (4). This is the percentage of known energy conservation technologies that are implemented *and* considered profitable by the firm. From a rational investment decision framework, this variable is the most important variable to be explained. Moreover, it appears that the profitable implementations make up 82% of all implementations. Thus, the investment behaviour is now defined as:

$$I_i = \frac{\sum_{j=1}^{6} P_{ij} * Y_{ij} * Z_{ij}}{\sum_{j=1}^{6} P_{ij} * X_{ij}} * 100\%$$

Note that investment behaviour is still defined as the ratio of weighted profitable implementation over weighted knowledge. All three main variables (knowledge, implementation and profitability) are included in this definition. The advantages of this definition are: 1) degree of implementation is weighed according to the potential savings of the implemented technologies; 2) because it is a scaled variable, results can be compared between sectors, even though these sectors might differ greatly. One disadvantage of this definition is that the investment behaviour is expressed as a percentage of *known* technologies. If, for example, a firms knows only one relevant technologies and has also implemented this technology, the degree of implementation is 100%, whereas a firm that knows all relevant technologies but implements only a few has a lower degree of implementation. In other words, this definition does not take into account the existence of a *knowledge gap*, the difference between what is technologically possible and what is known by the firms. Although getting insights into the determinants of the knowledge gap is very important, we will not address this question here because we would like to focus on the determinants of implementation of profitable energy conservation technologies.

3.2 Firm specific variables in the survey

In the second part of the survey the respondents were asked to answer questions in two categories. The first category contained questions to empirically test the hypothesized influences of firm specific variables on investment behaviour. The second category contains questions about the importance of certain variables in future energy conservation investment decision. From the questions the important variables can be stylized. For the first category, the variables can be grouped as follows (see appendix B for more details):

Economic variables	Energy related variables	Knowledge variables	Management Variables
1. Size of the firm 2. Hurdle rate 3. Different hurdle rates for energy conservation 4. Market expectations 5. Number and nature of financial sources[1] 6. Degree of competition 7. Budgetary constraints	1. Gas bill 2. Electricity bill 3. Energy intensity 4. Expected energy prices (1994 and 2000) 5. Fluctuation in energy prices 6. Relative energy efficiency	1. Number of information sources 2. Energy coordinator 3. R & D department	1. Organizational structure (type) 2. Position of energy management 3.Energy conservation as innovation reason 4. Priorities to cost-cutting 5. Premature depreciation

[1]. Own versus borrowed money

Table 2: list of potentially influential variables

All these variables can be empirically measured, either directly (such as size and energy bill) or indirectly (expected fluctuations in energy prices); continuous (e.g. energy intensity) or discrete (energy coordinator Yes/No). This provides us with the possibility to analyze the relations between a certain variable and the observed investment behaviour.

The second category of variables deals with potential barriers. It is, however, more difficult to directly analyze the relation between investment behaviour and variables from this category. The respondents were asked to state the importance of certain variables when a (future) energy conservation investment decision is made. For instance, if a firm states that having own financial sources is very important, does that mean that the firm finds this item important because it has plenty of financial sources or that it lacks the capabilities of generating own financial sources. In other words: is there a direct causal relation between stated importance and observed investment behaviour?

One possible way to answer this is to find a corresponding variable in the first category of variables and to analyze the relation between stated importance and observed actions. In the case of financial sources, we can 1) analyze the relation between investment behaviour and number & nature of financial sources; and 2) analyze the relation between number & nature of sources and the stated importance of having own financial sources. This procedure requires that there is a certain correspondence between variables in category 1 and 2. Unfortunately, this is not always possible due to some problems of quantifying variables in the second category. Below a list is given of stated importance (category 2) and their quantifyable equivalents. For each of the listed possible barriers the following coding scheme has been adopted (see table 3):

$$B_{ik} = \begin{cases} 0.9, & \textit{when considered very important} \\ 0.8, & \textit{when considered important} \\ 0.5, & \textit{when considered impartial} \\ 0.2, & \textit{when considered unimportant} \\ 0.1, & \textit{when considered totally unimportant} \end{cases}$$

where B_{ik} is the importance of barrier k to firm i, $(k=1,..,23;\ i=1,..,313)$.

Possible barrier (category 1)	Quantitative equivalent (category 2)
1. contribution to total profits	1. potential*energy bill
2. return on investment	2. PBP_{energy} hurdle rate
3. distance to core business	3a. PBP_{energy}-PBP_{core}
	3b. energy conservation as reason for innovations
4. size of energy bill	4. gas bill/ electricity bill (*1000 Dutch Gld)
5. uncertainty with new technologies	5a. number of information sources
	5b. development new technologies
6. own financial sources	6. reserves, earmarked budget
7. external financial sources	7. bank, LT-capital
8. uncertainty about future energy prices	8. spread between maximum and minimum expected energy prices (1994 and 2000; 1993=100)
9. low expected energy prices	9. minimum expected energy prices (1994 and 2000; 1993=100)
10. internal rules	10. type of organization (increases with complexity)
11. external rules	11. Sectoral long term agreement; external pressure
12. internal opposition	12. size; type of organization
13. market expectations	13. expectations index (1993=100)
14. degree of competition	14. possibility of calculating production cost increase in sales prices
15. required additional investment costs	15. budgetary problems
16. additional effort of implementation	16. average effort from ICARUS
17. additional effort for information collection	17a.number of information sources
	17b.energy coordinator
18. qualified personnel	18. organizational complexity/external energy coordinator
19. high standards of production quality	19. motive innovation: product innovation
20. high standards of production flexibility	20. motive innovation: production flexibility
21. high standards of working conditions	21a motive innovation: increase labour productivity
	21b motive innovation: reduction of labour costs
22. old equipment not yet fully depreciated	22. Premature depreciation allowance
23. environmental image	23. Environmental care system/ Int. energy coord.

Table 3: list of possible barriers and their quantitative equivalent

The idea behind this table is that there must be some consistent correspondence between the importance of barriers (on the left hand side) and the observed firm specific variables (on the right hand side). For example, a firm that states that uncertainty about fluctuating energy prices plays an important role in initiating energy conservation investments should, in our opinion, also state that it expects high fluctuations in future energy prices. If not, then the whole idea of testing barriers would fail. The empirical results of this correspondence test are presented in section 5.2.

3.3 Method of analysis

Because this is a preliminary analysis for finding relations, the simple techniques of partial correlation and OLS-regression are used. These techniques check for linear relationships between two variables. The assumption of linearity is made for reasons of simplicity. When OLS is used for a limited dependent variable, as in this case, the results may sometimes not be very accurate, because OLS can "push" the estimated variable over the natural limits, hence losing its interpretation. The normal way of dealing with this problem is to transform the limited dependent into an unlimited variables using the logistic transformation ln(y/(1-y)). However, this transformations does not work well in our case because there are many data points on the boundary (e.g. many zero implementations and 100% implementations, see figure 1.

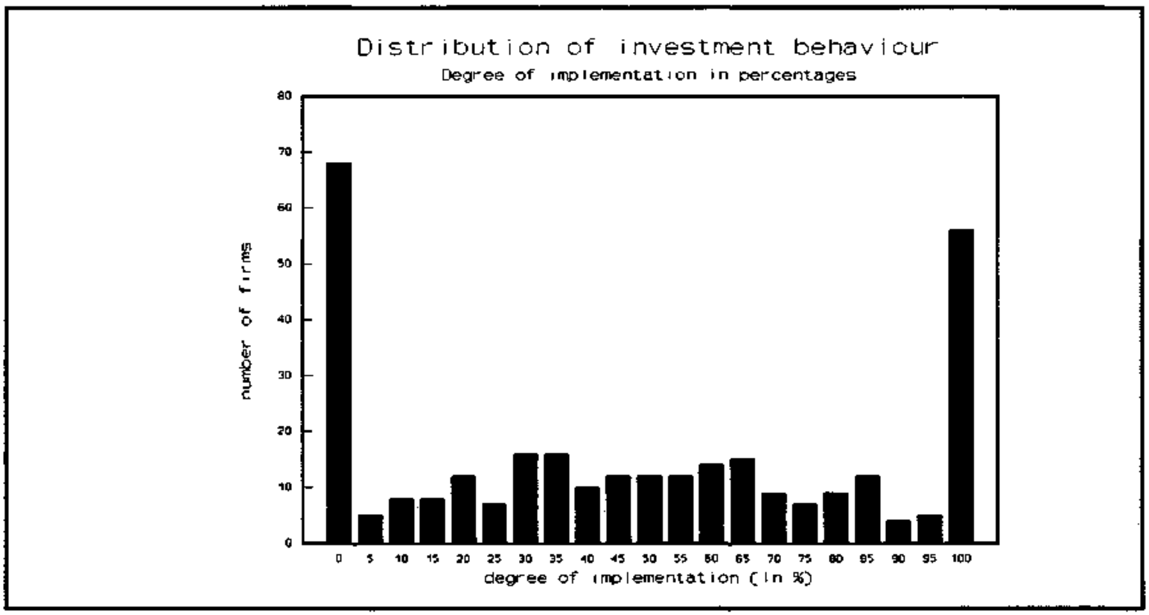


Figure 1: Distribution of implementation of firms

Logistic transformation breaks down at those data points. Therefore the decision was made not to transform these data, but to choose a slightly different approach. The approach taken is the following: first the whole data set is analyzed. Next the data set is divided into two parts: partial adopters (implementation between 0% and 100%), which we will refer to as **group A**; and full and non-adopters (implementation either 0% or 100%), which we will refer to as **group B**. In this group the two extremes are represented. If barriers exist, they should be most apparent in this group. OLS is used for the first group (with the possibility of transformation, since all the difficult data points are in the second part) and logistic regression for the second part. The results are then compared to see whether this approach is better than the result from the analysis of the entire sample. For each variable, we will argue what the influence is expected to be (positive/negative) Before performing the analyses, partial plots were made to get a quick picture of the empirical relation. These pictures are not included in this paper because the scatter plot are highly non-informative. This is an indication that some relations are less clear cut than theory suggests.

Table 3 links the observed firm specific variables to the stated importance of the potential barriers.

Comparing table 2 and the right side of table 3, one can see that all firm specific variables in table 2 can be found somewhere in table 3, which implies a coverage from observed firm specific variables to potential barriers. The other way around is less covered in our opinion, because the barriers are described in a more qualitative manner.

We proceed as follows: in the next section we discuss the results from the analysis of firm specific factors on investment behaviour. In section 5 we will analyze the relations as suggested in table 3 and also analyze the relations between the potential barriers and the observed degree of implementation. Section 6 will summarize the findings of sections 4 and 5 and present conclusions and recommendations for further research.

4. Empirical relations of determinants of investment behaviour

In this section we present the results of our experiences in finding relations between the observed variables (as listed in table 2) and the investment behaviour of firms. As mentioned above, we define investment behavior as the percentage of known energy conservation technologies that are implemented and considered profitable. This variable has its range from 0 to 100%. As our sample we use all respondents that have filled in information regarding a specific variable. The maximum sample space is 313 respondents. It is our goal to analyze which firm specific variables are suited to explain investment behavior. We present our empirical results in categories, corresponding with table 2.

4.1. Economic variables

Table 4 presents the results from the analysis of the influences of economic variables on investment decision. For each variable the expected and empirical signs are listed, as well as the significance of the influence.

Name of variable	Expected influence on EC-investments	Empirical influence in group A	Significance of influence in group A[*]	Empirical influence in group B	Significance of influence in group B
ln(size) in Dlf (*1000)	positive	positive	significant	positive	insignificant
PBP Cut-off points (in years)	positive	negative	insignificant	positive	insignificant
lower hurdle rates for energy conservation	positive	positive	insignificant	positive	significant by comparing group means
Market expectations index	positive	positive	significant	positive	insignificant
number of financial sources	positive	negative	insignificant	positive	insignificant
Nature of financial sources	dept=negative; equity=positive	negative; positive	significant	indecisive	insignificant

Market share	negative	no influence	insignificant	negative	significant
Possibility to include cost increase in sales price	positive	positive	significant	positive	significant
budgetary constraints	negative	positive	significant	positive	insignificant

Explanation of significance: significant: t-value > 1.5; semi-significant: 1.5 > t-value > 1; insignificant: t-value < 1.

Table 4: Results from empirical analysis

As can be seen from table 4, most of the variables have the expected influence. Size proves to be a good indication for economies of scale. In other words, small firms have less opportunities to invest in energy conservation technologies than large firms. Hence, we expect that the diffusion process for small firms is longer.

Also the variable market expectations has the expected sign. Firms with better market expectations show to be further in the adoption process than firms with poor market expectations. One explanation might be that good market expectations can lead to expansion of the capital stock in the most energy efficient way. Figure 2 shows the distribution of market expectations. Firms are modest in their expectations, which can lead to a slow adoption of energy conservation technologies in the near future. Bad financial situation and poor market expectations can be seen as an economic barrier for the adoption of energy conservation technologies.

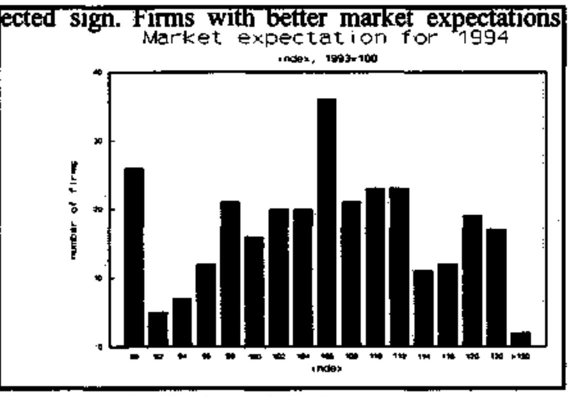
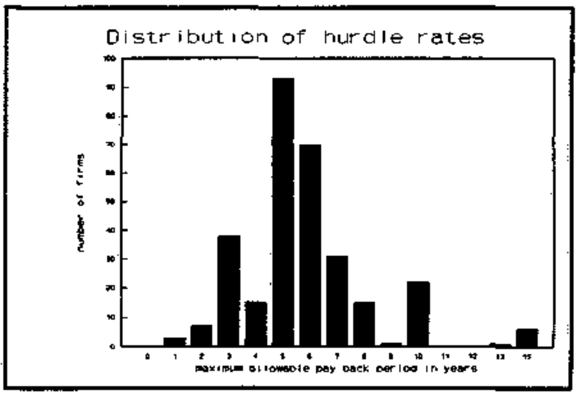


Figure 2 Distribution of market expectations

The nature of sources to finance investments seems to play an important role: firms who borrow money from the bank have implemented less than firms that were in a position to finance the investment out of own resources. Apparently the bank wants security and places strong requirements when firms try to obtain a loan. The fact that some firms are able to finance the investment without the help of an intermediary can also mean that their financial position is better than firms who need to go to a bank. Firms that rely on governmental subsidies for financing energy conservation technologies depend also on an "intermediary", and consequently also have a lower degree of implementation. The conclusion that can be drawn is that using an "intermediary" seems to hamper energy conservation investments, and is therefore a barrier to the adoption of energy efficient technologies.

There does not seem to be a direct relation between the degree of implementation and the maximum acceptable pay back period. One would have expected that this relation should be quite clear: lower hurdle rates lead to a higher degree of implementation. However, the implementation of profitable technologies does not only depend on the required minimum return on investment as posed by the firm, but also on the profitability of the technologies. In other words, one should take into account the cost-effectiveness structure of the energy conservation technologies, and analyze which technologies should have been implemented according to the minimum return on investment and the cost-effectiveness structure. Figure 3 shows the distribution of hurdle rates as stated by firms. The average hurdle rate is about 5 years.



Perhaps the most surprising result in table 4 is that firms who experienced budgetary problems seem to have a higher degree of implementation. The correlation between implementation and budgetary problems is quite high (rho=0.12). However, some inconsistent answers seem to have been given by the respondents. The correlation between implementation and using the bank as main source of funding investments is negative (which is in line with previous findings); the correlation between implementation and using reserves as main funding source is strongly positive (also in line with previous findings). Also the correlation between having budgetary problems and nature of financing investment is as expected: firms who fund with own money have less budgetary problems than firms who borrow from banks or depend on governmental subsidies. But previous findings suggest that the use of intermediaries hampers implementation, and this is in contrast with the fact that firms with budgetary problems (and thus often borrowing from banks) have a higher degree of implementation. The conclusion must be that the influence of budgetary constraints is vague.

4.2. Energy related variables

Table 5 presents the results from the empirical influences of energy related variables.

Variable	Expected influence	Empirical influence in group A	Significance	Empirical influence in group B	Significance
Gas bill	positive	none	insignificant	none	insignificant
Electricity bill	positive	none	insignificant	none	insignificant
Small users dummy	negative	positive	significant	none	insignificant
Energy intensity	positive	positive	significant	negative	insignificant
Minimum expected energy prices 1994	positive	positive	insignificant	positive	significant
Minimum expected energy prices 2000	positive	negative	insignificant	negative	significant
Dummy for expected price increases	positive	positive	significant	positive	significant
Fluctuation in energy prices 1994	negative	negative	insignificant	negative	significant
Fluctuation in energy prices 2000	negative	positive	significant	positive	significant

Relative energy efficiency	positive	positive	insignificant	positive	significant

Table 5: Results of empirical influences of energy related variables

A look at table 5 will give the reader a strange feeling: The energy bill does not play a relevant role in the determination of energy conservation investments. The theoretical reasoning that a large energy bill gives more incentive to save energy and consequently attracts investments towards energy conservation in not supported by this survey. The only variable related to absolute energy use is a dummy for small energy users, and it is even positive. Energy intensity (energy costs related to total production costs) is significant in group A but not in group B. This ambigious result causes to raise questions about the reliability of the stated influence.

Minimum expectations on 1994 energy prices show the expected positive correlation with implementation. Minimum energy prices secure the minimum profitability; higher minimum prices lead to higher minimum profitability. Minimum expected energy prices in 2000 have a counter intuitive sign. There we find the opposite relationship, where high minimum energy prices have lower degree of implementation. The relation is not very strong, though. This could indicate that the year 200 is too far away for firms to include it into their analyses.

Expected fluctuation is energy prices for 1994 tends to slow down the diffusion process, as higher fluctuations cause low implementations. Again the situation for the year 200 is not clear, probably due to a too far time horizon.

4.3 Knowledge variables

Variables in this group play "the odd-one out" role, because knowledge is already integrated in the definition of investment behaviour. Therefore, attention for this group should be modest, and we do not present a table with results, but rather discuss each of the variables shortly.

The number of information sources positively affects the investment decision. One explanation could be that many different information sources mean that the firm is able to make an adequate cost benefit analysis and can make a better assessment of risks of investing or that the firm is exposed more intensively to information. There could, due to the definition, also be a negative influence of the number of information sources on investment decision, because more information will lead to more knowledge about energy conservation technologies. That in turn will increase the denominator of the definition and hence decrease the degree of implementation. Apparently, this effect is offset by a better assessment of benefits and risks.

The presence of an internal energy coordinator does not influence the degree of implementation, at least not in a statistical way. Firms that do not employ an energy coordinator implement, on average, as much as firms who do employ an energy coordinator. This counter intuitive results must be viewed in the light of the survey sample. There are very few firms that have an internal energy coordinator. The additional revenues of employing an energy coordinator cannot statistically be proven. However, one would expect that the revenues to the firm of employing an energy coordinator will exceed the costs of yearly salary of an energy coordinator, and we must conclude that even though we cannot prove the additional revenues, we must assume that it must have its positive aspects. In a model, however, the variable "energy coordinator" is left out. Only large firms are in the position to employ an energy coordinator. The variable "Size", therefore, does not only incorporate economies of scale but also hidden effects, such as the presence of an energy coordinator. The same holds for an R&D department.

4.4 Management variables

The role played by management (or the structure of the firm) concerning investment decisions cannot be underestimated. They have the power to cancel a highly profitable investment project for many reasons. In section 2 we have listed some arguments that provides explanations why managers sometimes act in their own favour, thereby neglecting the goal of maximizing shareholder value. In this paragraph we analyze 5 variables connected with the structure of the firm: the organizational complexity, the position of the energy manager, energy conservation as reason for investing in new technologies, the priority for either expansion or cost cutting projects, the possibility of premature depreciation.

Organizational complexity is indicated by 3 dummy variables: simple complexity, moderately complexity, high complexity. We expect that although the complexity might bring incentives to managers to "cheat", the degree of implementation will be higher because of more specialized personnel. Thus, organizational complexity is not a proxy for "cheating possibilities", but rather a proxy for specialized personnel. This is supported by the survey where highly organized firms have invested more in energy conservation technologies[2]. The position of the energy manager does not seem to play a decisive role in the investment decision. It is also measured by 3 dummy variables indicating whether the (relative) position is high, middle or low[3]. There are no significant differences in the estimated parameters.

Remarkably, we found that firms who give high priority to cost cutting projects do not seem to have invested more in energy conservation technologies than other firms. In contrast, firms that have other reasons, such as product innovation or increasing product flexibility (called *expansion motives* as opposed to *cost cutting*), have invested more in energy conservation technologies. This result is counter intuitive, because energy conservation technologies are often initiated for cost cutting operations. Moreover, this counter intuitive finding is not a case on its own. Strangely enough, firms that mention reducing energy costs as one of the reasons for investing in new technologies seem to have a lower degree of implementation than other firms. One possible explanation might be that firms who are focussed on cost cutting are less open minded about innovations than firms who try to seek new market possibilities. Cost cutting is a defensive attitude (and sometimes conservative), whereas seeking new opportunities is thinking positive. Cost cutting is often not the real solution to the problem.[4]

The last variable that we consider here is the possibility of premature depreciation. Firms were asked whether it was possible to replace old equipment by new equipment before the old was fully depreciated. If this is possible, the autonomous replacement of technologies will be increased. History tells us that all new vintages of machineries are more energy efficient than its predecessor. Therefore we assume that when premature depreciation is possible, the degree of implementation will be higher. The possibility of premature depreciation is measured by 3 dummy variables, indicating whether it is possible, sometimes possible or totally impossible to have old equipment replaces before it is fully depreciated. The results from the survey show that firms who allow premature depreciation actually have implemented more energy conservation technologies. In other

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[2] Again, difficulties in interpretation can exist, because large firms often have a complex organisational structure. Thus the contribution of the positive effects on implementation of size and organisational complexity are somewhat intertwined.

[3] The position of the energy manager depends on the organizational structure of the firm. That is why the relative position of the energy manager is measured.

[4] In soccer there is a saying: "the best defense is offense".

words, refusing to replace an old vintage by a newer vintage can be a barrier for the adoption of energy conservation technologies.

4.5 Conclusions

At the end of this section we would like to summarize the results which were listed above. Table 6 presents the main conclusions from the analysis of influential factors, given the choice of the dependent variable. The variables have been ranked according to the importance of the influence on the dependent variable.[5] Variables that have a distinct influence are in the first column, whereas variables that have no empirically relevant influence on the investment decision are in the last column.

Most important variables	Moderately important variables	Unimportant variables
1. ln(size)	1. market expectations	1. hurdle rate
2. financing by bank	2. financing by subsidies	2. lower hurdle rate for energy conservation investments
3. financing with own money	3. number of information sources	3. market share/market leader
4. possibility to include cost increases in sales price	4. expansion as reason for innovation	4. energy bill
5. budgetary problems	5. dummy for expected increasing energy prices 1994	5. energy coordinator
6. spread between maximum and minimum energy prices	6. minimum energy prices 2000	6. R&D department
7. organizational complexity		7. position energy manager
8. premature depreciation		8. priority to cost cutting
		9. maximum energy prices

Table 6: Ranking of variables according to their empirical degree of influence

We find that some key theoretical variables, such as the energy bill and the hurdle rate, are not among the most important variables. Instead we find firm specific economic and organizational variables, such as size, the organizational complexity, premature depreciation and budgetary constraints as the most important determinants of energy conservation investment behaviour or barriers. Even among the group of moderately important variables energy related variables seem to be scarcely represented. This all leads to the conclusion that energy conservation investments are judged as "normal" investment projects, and that energy conservation investments face the same "barriers" as "normal" investments: where does the money come from to finance investments, how is the firm organized, is the old equipment fully depreciated? As expected the energy price does play a (small) role in the decision process, because it in fact determines profitability. However, the risk-aspect of the investment decision (the spread between maximum and minimum expected energy prices) is even more important.

5. Analysis of potential barriers

Above we analyzed the relations between the *observed investment behavior (expressed as the ratio of aggregated profitable implementation over aggregated knowledge)* and firm specific characteristics. However, these variables are some sort of *ex post* explanatory variables, that were assumed to have an effect on the investment decision. Below, we list the variables that play an important role in the (future) decision process for an energy conservation investment. In the first part we analyze which variables are considered important and we present a clustering of variables according to the empirical importance. In section 5.2 the results of the correspondence analysis are

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[5] Note that they are not ranked according to "sign" or determinant/barrier.

presented.

5.1 Empirical importance of potential barriers

For each of the variables the respondents were asked to state the importance of the variable for the initiation of an energy efficiency technology. It was measured on a ordered ratio scale with the following interpretation:
0.9 = very important; 0.8 = important; 0.5 = neither important, not unimportant; 0.2 = unimportant; 0.1 = totally unimportant.
The averages importance of each variable over the total sample was taken, together with the correlation with degree of implementation and size. By aggregating over sectors the different accents of important variables are evened out. Therefore for each variable the sectors which attach a higher and lower degree of importance are also listed. The results are presented in table 7.

Variable	average importance	correlation with investment	correlation with size	higher than average importance	lower than average importance
contribution to profit	0.70	-0.04	-0.165	meat, agricul.	health&educ.
return on investment	0.73	0.28	0.05	bulk, metal	other chem, health&educ.
distance to core business	0.45	0.17	0.04	meat	health&educ, metal
size of energy bill	0.63	0.08	-0.16	meat, agricul	building, bulk
uncertainty new technologies	0.47	0.11	0.07	food, bank and insurance	health&educ., metal
own financial sources	0.65	-0.05	-0.14	agriculture, health&educ	banks, other industries
external financial sources	0.51	0.03	-0.12	health&educ., agriculture	food, other chemicals
uncertainty future e-prices	0.50	-0.01	-0.02	food, retail, agriculture	bulk, other chemicals
low expected energy prices	0.45	-0.03	-0.07	agriculture	meat, bulk, building
internal rules	0.37	0.09	-0.03	health&educ., oth.chemicals	metal, bulk
external rules	0.46	0.14	-0.03	food, other chemicals	meat, bulk, metal
internal opposition	0.35	-0.01	0.06	health&educ.	building
market expectations	0.54	-0.1	-0.03	meat, agriculture, metal	health&educ. bank, retail
degree of competition	0.50	-0.01	-0.09	other chemicals, meat	health&educ., banks
required additional investment costs	0.65	0.04	-0.00	meat, agriculture, retail	health&educ., banks, bulk

additional effort for implementation	0.48	0.08	-0.05	meat, banks, retail	metal, other chemicals
additional costs of information collection	0.45	0.06	-0.07	other chemicals, bank	building, food
qualified personnel	0.49	-0.04	-0.03	meat, bulk	retail, metal
high standards of production quality	0.67	0.02	-0.07	meat, bulk, agriculture	health&educ. banks, metal
high standards of production flexibility	0.59	0.00	-0.04	meat, building	health&educ. banks, retail
high standards of working conditions	0.68	0.04	-0.03	meat, food, bulk	metal, banks, retail
old equipment not fully depreciated	0.61	-0.01	-0.1	retail, agriculture	meat, bulk
environmental image	0.63	0.05	-0.00	other chem.	metal

Table 7: Results of empirical importance of potential barriers.

From table 7 the most important variables can be derived. Given the coding scheme, variables that have an average importance of more than 0.6 are considered to be very important, an importance between 0.5 and 0.6 is considered moderately important. Variables with an average importance of less than 0.5 are considered not to be important. Hence, we can make a distinction in three groups. They are ranked and presented in table 8.

Most important variables	Moderately important variables	Unimportant variables
1. Return on investment 2. Contribution to total profit 3. Securing working conditions 4. Securing production quality 5. Availability of own financial sources 6. Additional required investment costs 7. Size of energy bill 8. Environmental image 9. Depreciation status of old equipment	1. Securing production flexibility 2. Market expectations 3. External financial sources 4. Uncertainty energy prices 5. Degree of competence	1. Internal opposition 2. Internal rules 3. External rules 4. Low energy prices 5. Distance to core business 6. Costs collection addit info 7. Additional time and effort 8. Uncertainty new technologies 9. Qualified personnel

Table 8: List of ranked importance of variables.

Among the most important variables is only one variable directly related to energy conservation (size of energy bill) and one related to the environment. The previous analysis showed that energy bill was not very important. From these results we conclude that energy conservation investments are judged as any other investment: mainly on an economic cost/benefit analysis. Even variables as uncertainty about energy prices and low expected energy prices play a modest role in the investment decision. In a way this seems inconsistent with the fact that they find return on investment very important, because the return of a stand alone technology is largely determined by the energy prices. On the other hand, it might be in line with the belief that revenues from energy conservation technologies are not only on energy conservation but also in other areas, such as production flexibility and labour flexibility.

From the column with correlations we can also see that firms who find return on investment very important also implement more energy conservation technologies. This could be evidence of the fact that there are many cost-effective energy conservation opportunities, and firms who make an extensive analysis of costs and benefits will indeed find that there are many cost-effective opportunities.

Another remarkable result is that firms do not seem to be bothered by the fact that energy conservation is not directly related to their "core business" activities. That is found not to be relevant. Moreover, firms who do find core business activities important seem to consider energy conservation as one of their core business activities, because there seems to be a positive correlation between implementation and importance of core business activities. This could be empirical evidence for the hypothesis that the importance of energy conservation is widely and well spread.

There is no empirical evidence that the concern for product quality, production flexibility and working conditions is hampering the implementation of energy efficient technologies, because the correlations are all very close to zero. These concerns tend to be less for bigger firms, as is also the contribution of an investment to total profit.

The availability of own financial resources is negatively correlated with the degree of implementation. This could imply that firms that find this issue important are having some trouble finding a way of financing the technological investments. The importance of this issue decreases with size of a firm. Bigger firm find own financial resources less important. Perhaps it is easier for them to get their money elsewhere.

The relation between premature depreciation and implementation is negative as expected, but very small. The correlation between the importance of full depreciation and size, however, is strongly negative. It means that bigger firms seem to be replacing old equipment sooner than small firms, hence implementing more energy conservation equipment. The effects of environmental image are positive but very small. The relation between environmental image and size is negligible.

5.2 Correspondence analysis

In the previous section a clustering was made into three groups of variables, according to their empirically proven importance. Here we would like to present the results from the correspondence analysis where we tried to match the observed variables tot the potential barriers. As stated before, the theoretical correspondence is not 100% clear in all cases, but it is tried to make the correspondence as close as possible. Table 9 lists the qualitative results from correlation analysis. The expectation is that all correlations are positive.

Possible barrier	Observed equivalent	Correspondence[1]
1. Contribution to total profits	1. N.A.	1. N.A.
2. Return on investment	2. Energy conservation hurdle rate	2. reasonable
3. Distance to core business	3. Lower hurdle rates for energy conservation/ energy conservation as reason for innovation	3. reasonable
4. Size of energy bill	4. gas/electricity bill	4. bad
5. Uncertainty new technologies	5. number of information sources /development new technologies	5. CI
6. Own financial sources	6. reserves	6. CI
7. External financial sources	7. bank	7.extreme good
8. Uncertainty about energy prices	8. spread between maximum and minimum expected energy prices	8. bad
9. Low expected energy prices	9. minimum expected energy prices	9. reasonable
10. Internal rules	10. type of organizational complexity	10. good
11. External rules	11. sectoral long term agreement/external pressure	11. good/ reasonable
12. Internal opposition	12. size/type of organization	12. good
13. Market expectations	13. market expectations index	13. bad
14. Degree of competition	14. calculation cost increase in sales price	14. good
15. Required additional investment costs	15. budgetary problems	15. good
16. Additional effort of implementation	16. Average effort from ICARUS	16. bad
17. Additional effort of information collection	17. number of information sources/energy coordinator	17. CI / reasonable
18. Qualified personnel	18. Type of organizational complexity / external energy coordinator	18. CI / bad
19. High standards of production quality	19. product innovation as reason for technological innovation	19. good
20. High standards of production flexibility	20. production flexibility as reason for innovation	20. extremely good
21. High standards of working conditions	21. increase labour productivity/ reduction labour costs	21. good
22. Old equipment not fully depreciated	22. premature depreciation allowance	22. good
23. Environmental image	23. environmental care system/ internal energy coordinator	23. very good

[1] Classification of correspondence:
extreme good: $\rho > 0.3$; very good: $0.2 < \rho < 0.3$; good: $0.1 < \rho < 0.2$; reasonable: $0.05 < \rho < 0.1$; bad: $\rho < 0.05$; counter intuitive (CI): $\rho < 0$; N.A: not available.

Table 9: Results from correspondence test

The correspondence of most variables is adequate, which is an ensuring thought. Nevertheless, there are some strange empirical results. For instance the low correspondence between actual size of energy bill and stated importance of energy bill in investment decisions. One explanation might be that the size of the energy bill plays an important role in energy conservation decision regardless of its size: if a firm has a large energy bill then the size is important because potential gains are high and the energy bill influences the investment decision positively; if the energy bill is small then it the investment decision becomes more delicate and the size of the energy bill can be the difference between implementing and not. Anyhow, the size of the energy bill plays an important role, leading to a low correlation.

There are also some counter intuitive relations. For instance, the number of information sources is positively correlated with the uncertainty of new technologies. One would expect that being strongly informed about energy conservation technologies would decrease the uncertainty of new technologies. We do not have an explanation for this result. Another remarkable correlation is the one between own financial sources and financing investments with own money. One would expect that when reserves are the main source of funding investments, the presence of own money to fund investment would play an important role in the investment decision. However, the empirical correlation shows that the importance of having own financial sources decreases with reserves being the main source of finance. One could conclude that firms who finance investments with their own money do not seem to bother about the presence of own financial sources. This idea seems to be supported by the fact that having own money is especially important to firms who lend money at the bank. Apparently, they would rather finance the investment with own means. Again, a bank as intermediary is not judged in a positive way.

Surprisingly, the correspondence between expected fluctuations and stated influence of fluctuations on investment decision is quite low. Firms who say that fluctuations are important when making an investment decision do not have higher expected fluctuations in energy prices. Consequently, we tend to conclude that high expected fluctuations can be a barrier in general, but as the expected fluctuations are quite small, they do not seem to play an important barrier in this survey.

5.3 Conclusions

Again, among the list of potentially most important barriers there are many variables that relate to "normal" business activities and not specially tot energy conservation. Product quality, working conditions and profitability of the invesment are among the most important factors that seem to influence the investment decision. Also the availability of financial sources and allowance for premature depreciation are very important. Low expected energy prices do not seem to play an important role. These results are less dependent on the definition of investment behaviour, and therefore more robust.

6. Summary, conclusions and recommendations

We have presented an empirical analysis of the potentially influential factors and barriers. Our analysis was a first attempt to find relations between investment behaviour and potential determinants of investment behaviour. Investment behavior was defined as the degree of profitable energy conservation implementations given a knowledge base. We tried to explain investment behaviour in two ways: first by correlation the degree of implementation and the observed firm specific variables, and secondly, by analysing the importance of potential barriers. We also tried to find an adequate correspondence between the observed variables and the stated importance of potential barriers.

Comparing tables 6 and 8 there are two important conclusions that can be drawn. The first and main conclusion is that energy conservation investments are no special investment cases, at least not when firms are only dealing with known energy technologies. The most important determinants of energy conservation investment behaviour do not seem to be specific to energy conservation: return on investment, budgetary constraints, premature depreciation, orginazational complexity are all "non energy specific" determinants. We tend to conclude that even though environmental image is one of the main determinants, investments are made on a cost/benefit analysis, just as every other invesment decision.

This conclusion is immediately followed by the second, and less positive conclusion: the major variables that determine the return on investment and risk of an energy conservation investment project are not among the most important determinants. This is not what we had expected. Minimum expected energy prices and low expected energy prices do not seem to play a prime role in the investment decision. The size of the energy bill looks like a non-relevant variable, and also other variables, such as energy coordinator and R&D department do not seem to contribute much to the energy conservation investment decision. Moreover, table 1 shows that the percentage of non-profitable energy conservation investments is not negligable, which needs us to put our first conclusion in perspective.

The theoretical arguments behind the potential determinants and barriers are nevertheless quite strong, and the contrast between theory and our empirical analysis is quite large. In other words, there has to be some explanation for the discrepancies between our findings and the theory. There are some possible answers. One is that the information in ICARUS is not in line with the information that firms have about implementation and profitability of energy conservation technologies. Firms are likely to make different assessments about returns and risks. Moreover, the information in ICARUS is a sectoral level, whereas our survey is on the firm level. The difference in focus of analysis can lead to substantial differences (especially regarding individual costs of initiating or replacement). Further research is needed to increase the interactions between ICARUS and our survey.

A second explanation for the differences in findings is that the answers in our survey are less consistent than we would have liked. Some of the questions appeared to be too difficult to answer. Some respondents made a "lucky guess". Many questions are on a qualitative scale which always introduces more inaccuracy than continuous variables. Dealing with these qualitative variables as if they were quantitative can lead to problems of interpretation.

Of course, the biggest inaccuracies are made when one tries to capture "investment behaviour of firms" in one single number or variable. The conclusions of our analysis thus depend heavily on our definition of investment behaviour. Other definitions might lead to other results. Sensitivity analysis is one topic of further research. However, we tend to conclude that *within our definition* of investment behaviour a "normal" micro economic cost benifit approach is in order.

The conclusions that we have drawn might have some reprecussions on governmental policy. Instead of labelling energy conservation as part of a national environmental strategy, energy conservation policy should direct itself on economic instruments, and less on bilateral negotiations and agreements, for which the monitoring system is very costly and unreliable. Economic instruments, such as energy taxes will place more incentive and could push the energy price over a certain point were prices does become important. Another line of attention is to somehow make it easier for firms to get the money for the investments. However, one should be cautious with subsidies or other financial incentives because the free rider problem still exists. A good way of monitoring has not yet been found.

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Appendix A: Coding scheme for Dutch sectors

Ducth sectoral code	(Sub)Sector	Merging Sectors
2021	diary	1
2051	sugar	1
2061	oils, fats	1
2129	fodder	1
2011	public slaughter houses	2
2012	wage slaughter houses	2
2013	other slaughter houses	2
2014	meat	2
2113	fodder	1
2151	breweries	1
2152	malthouses	1
22xx	textiles	3
25xx	furnitures	3
26xx	paper (bulk)	5
27xx	graphical	3
2811	refineries	4
2821	cokes	4
2911	fertilizers	4
28xx	petrochemical	4
2942	anorganic chemicals	4
2961	medicines	5
2991	glue	5
2921	other chemicals	5
2971	soap	5
3211+3212	brickes and tiles	6
3224	potteries	6
3251	cement	6
3281+3282+3283+3284	glas	6
32xx	other building materials	6
33xx	iron and steel	7
3341+3342+3343+3344+3402	no ferro	7
34xx	other metal	7
81xx	banks	8
82xx	insurance	8
83xx	office buildings	9
67xx	catering	9
65xx, 66xx	retail	9
0111	agriculture	10
121/127	horticulture	10
miscel.	health	11
miscel.	education	11

Appendix B: Description of Database

Variables that should/could explain investment behaviour
Here, we list the most important variables from which we have individual data.

Variable	Unit of measurement
size (annual turnover)	in millions of Dfl
sector code	dummy variables for 11 sectors
electricity-bill	in thousands of Dfl
gas-bill	in thousands of Dfl
total energy bill (also oil if present)	in thousands of Dfl
energy intensity	estimated percentage of energy costs in total production costs
function of respondent	financial/general/technical/energy/investment management
main criterion for investments	PBP/NPV/IRR/simple CB/non-economic
minimum return on investment	PBP cut-off point (in years)
subjective idea of exploited potential	enough/adequate/less than adequate/no more possibilities
subjective idea of exploited good housekeeping	enough/adequate/less than adequate
reasons for investing in technological innovation	increase turnover/ energy savings /labour savings /capital savings/increase productivity/ increase flexibility
reasons for investing in energy conserv. innovation	increase turnover/ energy savings /labour savings /capital savings/increase productivity/ increase flexibility
information sources	number of used information sources {1,..,12}
minimum expected energy price 1994 and 2000	index (1993=100)
maximum expected energy price 1994 and 2000	index (1993=100)
additional energy efficiency due to temporal 50% resp. 100% increase e-prices	percentage of total energy bill to be reduced due to higher energy prices
additional energy efficiency due to structural 50% resp. 100% increase e-prices	percentage of total energy bill to be reduced
possibility of increasing sales price	totally possible/ partially possible/ impossible
ways of financing investments	bank/ capital market/ issuing stock/ savings/ subsidies/ special budget
budget problems (cancellation of project due to liquidity constraint)	1=yes; 2=no
premature depreciation	yes/no
relative energy efficiency	more/equal/less than average in sector

R & D department	yes/no
energy coordinator	internal/external/non/both
sectoral long term agreement	number of years (0=no agreement)
frequency energy check	number of times per year (0,1,2,4,6,12,52,300)
decisive power energy conservation investments	financial/ general/ technical/ energy/investment management
environmental care system	yes/no
external pressure	yes/no
effects market expectations on EC-investments	positive/negative
type of organisation	simple/normal/advanced
effects strong competition on EC-investments	positive/negative

Potential barriers

Here we list a number of variables that firms might experience as being an obstacle for implementation of energy conservation options. For each of the following items this question was asked:
When initiating an energy conservation investment, how important is the following item with regards to the actual decision?
(0.1=totally not important; 0.2=not important; 0.5=average importance; 0.8=important; 0.9=very important)

The following items were presented:
a. contribution of investment to total profits
b. return on investment
c. extent to which an investment belongs to core business activities
d. size of energy bill at the moment
e. uncertainty regarding new. unfamiliar technologies
f. capacity of own financial resources
g. possibility of external financial resources
h. uncertainty regarding future energy prices
i. low expected energy prices
j. internal rules
k. external rules
l. internal opposition
m. market expectations
n. degree of competition
o. additional investment costs
p. additional effort
q. additional time and costs to get new information
r. educated personnel
s. keeping product quality
t. keeping production flexibility
u. keeping good labour environment
v. present techniques have not been fully depreciated
w. environmental image

1992-1	R.J. Boucherie N.M. van Dijk	Local Balance in Queueing Networks with Positive and Negative Customers
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