ENERGY SAVING BY FIRMS: DECISION-MAKING, BARRIERS AND POLICIES

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Abstract.

Promoting investments in energy saving technologies is an important means for achieving environmental goals. Unfortunately, the empirical evidence on success conditions of policies is scarce. Based on a survey among Dutch firms, this paper sets out to identify the factors that determine the investment behaviour of firms, their attitude towards various types of energy policy, and their responsiveness to changes in environmental policy in the Netherlands. On the basis of discrete choice models, this paper aims to investigate empirically whether (and how) these strategic features vary over firm characteristics and over sectors.

JEL-codes: D20, Q40, Q48

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1. Introduction

Environmental quality and resource management has become a prominent challenge in a modern economy. The complexity involved has prompted a series of diverse policy initiatives, ranging from market oriented instruments (e.g., Pigouvian taxes, tradeable permits) to command and control measures. The pros and cons of such policies have been extensively mapped out in the literature (see for a general overview Tietenberg et al., 1999). In practice, many policy initiatives were flawed by much uncertainty (see e.g. Roberts and Spence, 1976; Adar and Griffin, 1976), so that a clear choice for price-based instruments – as opposed to quantity-based instruments – could no longer be sustained. Consequently, we have seen a formidable variation – over time and among countries – in the application of policy instruments and measures. This also holds for a country with a traditionally strict environmental policy, the Netherlands.

With varying degrees of priority, environmental problems are still high on the Dutch policy agenda. In recent years, Dutch environmental policy has been relatively successful, at least in the reduction of emissions of some pollutants. Despite a strong economic growth performance, many emissions of pollutants have been reduced. This improvement is to a large extent the result of a more intensive use of environmentally-friendly technologies, the adoption of which was stimulated by the imposition of clear policy objectives, task requirements, and voluntary agreements. Despite these improvements, several serious problems still remain. The most pressing problems in the Dutch situation are associated with climate change, noise, and eutrofication. Additional policies are still required to reach the targets that have been set in the so called *NMP3* (the most recent Dutch national environmental plan).

In this plan, the Dutch government opts for more intensive use of voluntary agreements, but also for using and exploiting market-based incentive mechanisms. The general goal here is to better reflect environmental decay in prices so as to encourage behavioural changes. Fiscal measures should result in product prices that more properly mirror the (marginal) social costs associated with the use of energy. These additional measures should result in adjustments in producers' and consumers' behaviour, product and process innovations, and a lower use of scarce environmental resources. In order to assess and judge

the desirability, the effectiveness and the acceptability of such proposed policy changes, it is of critical importance to obtain clear empirical insights into the way investment decisions in general, and energy use in particular, emerge within firms, how these decisions can be influenced by governance strategies, how firms would respond to various possible policies, and how they judge the feasibility and acceptability of these measures. Against this background, the present paper will address the potentials and impediments of energy-saving strategies among firms by a series of empirical results originating from the analysis of a survey among Dutch firms, dedicated to success conditions for energy savings.

Detailed systematic empirical studies at a sectoral or firm level are rather scarce in the Netherlands. Some years ago, for instance Velthuijsen (1993) and Gillissen et al. (1995) performed also a questionnaire among firms, in which they also focussed on energy use and related investments. Our research broadens their scope in that we do not only focus on investment behaviour, but also on the stated response to and attitudes towards a set of specified policy instruments. Our new data set allows in addition for a more detailed analysis of the role of various types of uncertainty in investment decisions, which, according to investment theories as developed by, for example, Dixit and Pindyck (1994), may be a major explanatory factor for seemingly irrationally high revealed internal discount rates in investment evaluation (see, for example, Johnson (1994)). It thereby aims at broadening our understanding of decision-making on energy use in companies and energy gaps as have been widely documented in the literature. The 'background variables' in our study, however, that are necessary for statistical analysis, are deliberately largely similar to those in the above mentioned studies.

The survey was held in the spring of 1998 among Dutch firms. These firms were randomly selected from the register of the Chambers of Commerce and were more or less equally distributed among the most energy-intensive sectors of the Dutch economy, namely the chemical industry, basic metals, metals and machinery, food, paper, horticulture, construction materials, and textiles. The extensive survey contained a detailed set of questions about energy use, investments, the firm's competitive position in the market, internal decision making, its attitude towards and adoption of energy saving technologies, as well as its attitude towards and responsiveness to Dutch environmental policy. The statistical results also

incorporate a body of empirical knowledge on the expected effects and acceptability of energy policies, two major determinants for the viability of environmental and energy policies.

In this paper we will present the results of the above survey and investigate how investment behaviour, attitudes and responsiveness towards economic policy, as well as barriers to the adoption of readily available energy efficient technologies, vary over sectors and with firm characteristics. Our analysis will be presented in five separate sections. Section 2 discusses the survey and gives a description of the firms and sectors included in the sample. Section 3 considers the investment behaviour of firms, along with the perceived barriers to investing in cost effective energy saving technologies (in the context of the so-called energy efficiency paradox). In Section 4, attention is shifted to how firms stated to react in response to an increase in energy taxes on a national level (with no rebatements). Section 5 discusses next the attitudes towards environmental policies in the Netherlands. Section 6, finally, contains an evaluation and presents the policy conclusions emerging from our empirical analysis.

2. The survey

The survey resulted in a data set of 135 companies (i.e. plant locations) established in the Netherlands. Firms in nine sectors of the economy were randomly selected, and received a 15 page survey in May 1998. Confidentiality was guaranteed. The survey asked firms about their characteristics (size, profitability, residential sector to which it belongs, number of employees, export share, etc), their energy use (in monetary and volumetric equivalents), their investments (in general, and purely aimed at energy efficiency improvements), their position in the market (strength of competition, location of competitors, how the firm compares to competitors in terms of size, sales, profitability, etc), their focus in policy making (importance of short- and long-run profitability, reduction of labour and energy costs, improvement of environmental image, increase in sales, etc.), their expectations about the development of costs of inputs, their knowledge, implementation and use of energy saving technologies, their attitudes towards and willingness to accept energy policies of various types (voluntary agreement, taxes at national and international level, subsidies, standards, etc.), and their R&D behaviour

(expenditures, degree of cooperation and outsourcing, size of R&D staff, criteria for project selection, etc.). Firms were divided over the following nine sectors: the chemical industry, basic metals, metals, machinery, food, paper, horticulture, construction materials, and textiles. In the remainder of this paper, we will distinguish 7, more aggregate sectors, namely the chemical industry (18 % of the sample; further labelled as CHEM), basic metals (10 %; BASEMET), metal products (11 %; MET), food (14 %; FOOD), paper (7 %; PAPER), horticulture (24 %; HORT), and the rest (REST) consisting out of machinery, construction materials and textiles.[2]

Table 1 summarises relevant information on some key characteristics of the firms in the various sectors under investigation. The categories according to which firms are distinguished are their share of energy costs in total sales, their investments as a share of sales, their profits as a share of sales, the number of employees, their perception of competition (ranging from limited (score 1) to intensive (score 3)), and the location of their competitors (ranging from mainly in the Netherlands (score 1) to virtually all abroad (score 4)). A first statistical experiment concerned the explanation of the above set of firm characteristics from a set of sectoral dummies. Statistical significance in the table indicates that a particular firm characteristic deviates significantly from the sample average in the industry under

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     [2]   The overall response rate was 4.2 %. Response rates per sector differed considerably. They ranged from 1.46 % in the textile industry to 8.73 % in horticulture. Although admittedly low, such a response rate is common and acceptable for this kind of extensive survey research (compare, e.g., Vicini (1998)). A first rough analysis of the data gives no reason for suspecting serious selection biasses in the sample. Furthermore, for the ultimate goal for which the survey was held, namely studying how decision making, barriers and attitude towards policy *vary* over different firms and sectors, we suspect no serious effects of a potential selection bias. Clearly, some caution is needed when generalizing the results. Data on size in terms of employees, energy intensity, and profitability were confronted with available evidence from the Dutch Statistical Bureau (CBS) in '*De Nederlandse Energiehuishouding, Deel 2*' (Table 9). Although the data are not fully comparable (our measure of size is the number of people working in a firm, independent of whether they work part-time or not, and the CBS reports gross returns before taxation while we have data on net profitability), they suffice to express some confidence in the representativeness of our data set. The means reported in Table 1 do not differ significantly from the reported sectoral averages by the CBS for energy intensity and size (at a significance level of 5 %). Also, the relative order of magnitude of these variables according to the CBS is comparable to the order of magnitude in our sample. From the respondents within the firms, 75% was associated with energy, investment and/or technological management. Only 11% of the firms that responded had an energy coordinator, from which we may conclude that firms which are already explicitly working on their energy management are not overrepresented in the sample (compare Gillissen et al., 1995; Table 6.3). More detailed information on this analysis is available upon request from the authors.

investigation. The parameters reported in the table were estimated using OLS, where the independent variable was the deviation of a firm's score from the sample average, and the independent variables were all sectoral dummies (note that no constant was used, as deviations from the sample average were considered). A comparable procedure will be used below, when the variation over sectors is considered. The sum of the sample average and the sector-specific effect yields the average score of a specific variable in that particular industry.

Table 1. Firm characteristics versus sectors: OLS

FIRM CHAR..	Sample average	CHEM	BASEMET	MET	FOOD	PAPER	HORT	REST
OBSERV	135	24	13	15	19	10	33	21
ENQ	0.10	-0.01	-0.06	-0.08	-0.07	-0.06	+0.14[***]	-0.08
INQ	0.11	-0.04	-0.02	-0.07	-0.06	+0.09	+0.09[**]	-0.05
PRQ	0.03	+0.02	+0.05	+0.03	+0.08	+0.08	-0.17	+0.10
LABOUR	279	+285	+758[**]	-233	+111	-218	-253	-227
LLABOUR	3.16	+1.67[***]	+1.50[***]	-0.19	-0.08	-0.21	-0.95[***]	-1.05[***]
COMP	2.42	+0.13	+0.17	-0.28[*]	-0.05	-0.12	+0.21[*]	-0.30[**]
COMPIN	2.23	+0.99[***]	+0.85[***]	-0.23	-0.87[***]	+0.33	-0.16	-0.70[**]

*/**/***:   significant at the 0.1/0.05/0.01 level (two-sided t-test) in OLS regression with sectoral dummies

VARIABLE DESCRIPTIONS

OBSERV	Number of observations;
ENQ	Energy intensity (expenditures on energy as percentage of sales);
INQ	Investment ratio in 1997 (total investments as percentage of sales);
PRQ	Profit ratio (total profits as percentage of sales);
LABOUR	Number of employees (full time and part time);
LLABOUR	Log of number of employees;
COMP	Degree of competition on sales market (1=limited, 2=average, and 3=strong);
COMPIN	Location of competitors (1=mainly in Netherlands, 2=less than 50% abroad, 3=more than 50% abroad, 4=virtually all abroad).

From this table, it is evident that horticulture is the most energy intensive sector with relatively small firms, and invests - relative to profits - significantly more than firms in other sectors. In addition, competitive forces in horticulture are perceived as strong (especially on the national market). The chemical sector and the sector producing basic metals can both be characterised by larger-sized firms and the fact that most of their competitors are located abroad. In contrast, firms in the food sector and machinery, construction materials, and textiles indicate that most of their competitors are located in the Netherlands.

The column variables reported in Table 1, referred to as 'firm characteristics' in the sequel, appear to be often strongly correlated. Especially the degree of competition and the

location of competitors are strongly positively correlated, while the profit rate and the energy intensity are strongly negatively correlated. This may create statistical problems in the multiple regression estimation of models, due to the presence of multicollinearity. We will evade this problem in the remainder of this paper by restricting the reported results to simple regressions. The focus is therefore on the overall impact, not the marginal effect, of these variables on the response variables studied. In the same vein, we will report separate estimations of the effect of (the full set of) sector dummies on the response variables. In the context of the type of questions studied, the advantage of this approach is that the 'full' effect of the independents on the dependants is determined. The interpretation of marginal effects is probably less relevant from a policy perspective, in particular because the independents considered simply *are* correlated in reality. The estimation results obtained with multiple regressions would cloud these correlations. Moreover, it should of course be acknowledged that the data set is simply too small to allow for multiple regressions taking all possibly relevant variables on board, in particular if more advanced statistical techniques such as 2SLS were used.

3. Investment behaviour and barriers to investment

We will now turn to the stimuli and barriers concerning firm investments. In one of the central parts of the survey, firms were asked about their investment behaviour, and the factors that they perceived as preventing them from investing in energy saving technologies that were considered, but that were nevertheless not (yet) adopted.

The share of total investments that is spent on technologies that are *purely* aimed at energy saving is low at first sight (on average slightly below 10 %), but at the same time, these shares do not significantly differ from the share of energy costs in total sales. Most firms in the survey indicate that energy efficiency is an important factor in their investment decisions. Furthermore, Figure 1 reveals that, at least in the firms' own perception, there is no systematic under- or overestimation of the relative importance of energy efficiency in overall investment decisions. It is therefore possible that substantial further energy saving may still take place by incorporating energy efficiency as a decision variable when installing new machines or buildings. This conclusion was further confirmed by asking firms about their future investment

behaviour. It turned out that most firms expect the total investment budget to remain largely constant (or to increase slightly). This also holds, but to a lesser extent, for investments purely aimed at increasing energy efficiency. However, the importance of energy efficiency in investment decisions is expected to increase (albeit slightly). One may therefore conclude that, according to the respondents, energy efficiency becomes an integrated and important aspect of the overall evaluation of investment opportunities (we will return to this below when we discuss barriers to investments).

< Insert Figure 1 around here >

Before proper investment decisions can be made, adequate knowledge is required on the various alternative investment opportunities. Lack of information is a principal source of market failures that can account for sub-optimal investment behaviour. To obtain knowledge on suitable technologies, most firms turn out to rely on specialist publications. Also direct contacts with suppliers, the industrial board and colleagues appear to be intensively used to gather information. Formal organisations like the government and NOVEM (the Dutch organisation of energy suppliers) play only a minor role in providing firms with information. As far as perceived knowledge is concerned, about 30 % of the firms indicate that they are not, or only to a minor extent, aware of existing new technologies that are not yet being used in practice by any firm. Of course, a smaller percentage of 20 % have only limited knowledge on technologies that are currently used by other firms. These results suggest that future policy can improve upon the situation by providing firms with relevant information on investment possibilities in energy saving technologies. The public nature of information provides of course good arguments for such a governmental role in providing and disseminating information.

It is often argued that small firms are in a particular disadvantageous position in obtaining strategic information on new and already existing technologies. In order to obtain information on whether the perceived knowledge varies over sectors and over firms with particular characteristics, we have regressed the perceived knowledge on sector dummies and firm characteristics. The results are shown in Tables 2a and 2b. In Table 2b, we report simple

ordered probit estimates.[3] As already mentioned at the end of Section 2, we restrict our attention to simple estimates, as the explanatory variables are characterised by collinearity.

Table 2a. Perceived knowledge on available technologies: sectors, OLS

KNOWLEDGE	Sample average	CHEM	BASEMET	MET	FOOD	PAPER	HORT	REST
Know_exist	3.18	+0.28	-0.35	-0.58**	+0.01	+0.04	-0.32	-0.07
Know_new	2.79	+0.33*	-0.04	-0.39	-0.38*	+0.01	+0.15	+0.01

*/**/*** indicates significance at the 0.1/0.05/0.01 level (two-sided t-test) in OLS regression

VARIABLE DESCRIPTION

Know_exist   knowledge on already existing technologies that are currently being used by competitors;
Know_new   knowledge on new technologies that are not yet being used in practice.

Table 2b. Perceived knowledge on available technologies: firms' characteristics, simple ordered probit

KNOWLEDGE	Sample average	Energy quote	Investment quote	Profit quote	Size	Competition	International orientation
Know_exist	3.18	+0.34	**+1.44****	+0.03	**+0.11****	**+0.25***	**+0.20*****
Know_new	2.79	+0.61	**+1.23****	-0.04	**+0.10****	**+0.29****	**+0.27*****

*/**/*** indicates significance at the 0.1/0.05/0.01 level (two-sided t-test) in simple ordered probit regression; Bold estimates indicate that the sign of a significant parameter in the simple regression is 'robust': no significant parameter of the opposite sign is found for this variable in multiple regressions

Several results shown in the tables are noteworthy. First, the firms' knowledge on both new and already employed technologies is particularly high in the chemical industry, while it is low in the metal and food industry. Secondly, such strategic knowledge is especially high in large firms that invest heavily and are faced with strong competition. This last result is particularly interesting, as it reveals that there is some truth in the argument that competition indeed functions as an incentive generating mechanism, forcing firms to obtain strategic information. Although it has to be acknowledged that the causality might run both ways, also the positive correlation between knowledge and total investments is conform our expectation. These results are in clear contrast with Gillissen et al. (1995), who conclude that the information gap

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[3]   Ordered probit estimation properly takes account of the fact that the independent variable can take on only discrete values. The interpretation of the coefficients in the Table 2b, however, is difficult (this is a notorious problem with ordered probit estimates; see for example Greene, 1997). This is exactly the reason for using OLS when considering the sector dummies: the estimated parameters can easily be interpreted as the sector-specific difference in average score (compared to the entire sample). In the text, when discussing ordered probit results, we restrict the analysis to the sign and significance of the obtained parameter values. More detailed information on the estimates is available upon request from the authors.

is largely sectorally determined. Our analysis reveals that the information gap is particularly large in small firms facing limited competition and spending relatively little on investments. There is some sectoral effect in that firms with these characteristics are over-represented in the food and basic metals industry, and underrepresented in the chemical industry. Our results are largely in line with Gruber and Brand (1991) who performed a study on, among others, knowledge on technologies in German small and medium-sized firms.

Although knowledge about and expected profitability of available technologies are necessary conditions for implementation of new technologies, they are not sufficient. There may be a host of barriers that still prevent the firm from (immediately) investing and result in an 'energy gap'. The optimal timing of the adoption of new technologies is an important issue in the economic literature (see, e.g., Farrell and Saloner, 1986; Choi, 1994; Koski and Nijkamp, 1998), especially in the presence of so called forward and backward externalities. The estimation of the expected installed base of adopters of a new technology and the costs and benefits of waiting for a new technology are a major source of uncertainty. Figure 2 shows the relative importance of barriers to adoption. Scores range from 1 (barrier is completely unimportant) to 5 (barrier is very important). The responses shown here concern technologies about which firms had indicated earlier in the survey that they are aware of their existence, that were considered as being profitable, but that were still not implemented as yet. Three main categories of barriers can be distinguished: general barriers related to the overall decision-making of firms with respect to production and investment, financing constraints, and barriers that are related to uncertainty about, for example, future technology, prices and policy developments, and the quality of the new technology.

< Insert Figure 2 around here >

The most important barrier for firms is the existence of other investment opportunities that are considered more promising or important. Especially if financial or organisational constraints play a role, investments in energy saving are likely to be pushed aside in favour of other, more attractive, investments. Also resistance to replace existing machinery turns out to be an important obstacle. This suggests that in the future, considerable improvements can still be made, once old machinery is going to be replaced due to obsolescence. Also, the relatively

small amount of money spent on energy is acting as a barrier to investing in new technology. Apparently, the costs of acquiring information and incorporating the new technologies within the firm often exceed the expected savings on the energy bill. Lack of financial means to finance the investments turns out to be a problem of relatively minor importance. Uncertainty is of intermediate importance. An important fear that firms have is that future technologies will be significantly better or cheaper. This generally induces a postponement of investments. Part of the uncertainty is also related to policy and results from uncertainty about future subsidies or environmental requirements. Figure 3 shows that cost savings due to lower energy use are the most important driving force for investing in energy saving technologies. Policy measures like subsidies and fiscal arrangements may be supportive in steering investments towards higher energy efficiency.

< Insert Figure 3 around here >

The next step in our analysis was to test whether the barriers to investing in energy-efficient technologies differed between sectors (Table 3a), and whether these barriers differed according to firm characteristics (Table 3b). The estimation technique used in Table 3a is comparable to the technique underlying Table 2a, while the estimation technique employed in Table 3b is comparable to the one in Table 2b.

It is evident from Table 3a that there are only a few barriers that play a systematically different role in different sectors. The only two sectors that stand out somewhat are the basic metals sector and horticulture. The general barriers play a relatively important role in the sector producing basic metals. It appears from the results that current installations are thought to be sufficiently efficient from an energy point of view and that the willingness to replace them is (therefore) fairly low. An opposite pattern can be found in horticulture. In this sector, current installations are thought to be insufficiently energy efficient and there are no problems in that current installations initially have to be replaced which can be explained from the extremely high energy intensity of this sectors. Problems do exist in this sector however, in that organisational constraints prevent the introduction of new technologies. The importance of organisational factors for understanding the energy efficiency paradox has been stressed by, for example, DeCanio (1993).

The extent to which barriers to invest to invest in energy saving technologies vary with firm characteristics is described in Table 3b. As one would expect, the general barriers play less of an important role in energy intensive firms (except for the organisational barriers, which is strongly driven by the fact that horticulture is energy intensive and faced with organisational barriers). A surprising result is that weight attached to barriers by profit making firms is relatively large. Especially the barriers associated with uncertainty seem to refrain profit making firms from investing. A potential explanation for this result is that the profitable firms in our sample tend to be the energy extensive firms. As we saw before, these firms attach more weight to the various potential barriers to invest in energy saving technology, which makes clearly some sense. Another explanation may be that more profitable firms do consider uncertainty more explicitly when making investment decisions. Economically better management would then jointly explain both the high profitability and the consideration of uncertainty. A similar argument could explain why these firms less often state that energy efficiency is less important *per se*.

Similarly surprising is the fact that large firms attach a relatively large weight to general barriers (except for organisational barriers, which may again reflect the fact that horticulture is characterised by organisational barriers and relatively small firms). Finally, competitive forces turn out to affect the importance of reasons for not adopting energy saving technologies. In particular, more competitive firms tend to be faced relatively stringently with organisational barriers and also tend to abstain from technology adoption due to various sources of uncertainty (especially the fact that technologies may become cheaper in the future which makes it advantageous to wait).

Table 3a. Barriers for implementation of energy saving technologies: sectors, OLS

BARRIERS	Sample average	CHEM	BASEMET	MET	FOOD	PAPER	HORT	REST
GENERAL								
OthIm	3.74	-0.10	+0.48	-0.03	+0.59	-0.24	-0.44	-0.34
AftRe	3.51	+0.09	+0.71*	-0.34	-0.01	-1.01	-0.61*	+0.74
EnCo	3.35	+0.35	+0.03	+0.08	+0.15	-0.35	-0.17	-0.55
LoPrio	3.08	+0.10	+0.17	-0.23	+0.25	-1.08	-0.31	+0.52
CurEf	3.00	-0.20	+0.63*	0.00	-0.67*	-0.50	-0.08	+0.75
NowIm	2.96	-0.16	-0.33	-0.79	+0.24	+0.04	+0.29	+1.38
Organ	2.83	-0.20	+0.29	-0.33	-0.67	-0.33	+0.87**	-0.43
FINANCE								
IntBu	2.66	-0.10	+0.45	+0.63	+0.17	+0.34	-0.46	-1.16*
ExtBu	2.22	-0.22	-0.34	+0.62	+0.58	+0.28	+0.08	-0.62
UNCERTAINTY								
UnQua	2.71	-0.31	+0.67	-0.38	-0.14	-0.21	+0.09	+0.09
Sub	2.54	-0.14	-0.17	-0.38	-0.11	+1.46*	-0.04	+0.66
Cheap	2.48	+0.02	+0.27	-0.48	+0.38	-0.48	+0.22	-0.68
Overv	2.38	-0.48	0.00	+0.20	+0.29	+0.63	-0.08	+0.23
Wait	2.35	-0.45	+0.27	-0.52	+0.36	-0.35	+0.35	+0.05
Norms	2.33	+0.07	+0.17	-0.73	+0.51	+0.17	-0.03	-0.33

*/**/*** indicates significance at the 0.1/0.05/0.01 level (two-sided t-test) in OLS regression

VARIABLE DESCRIPTIONS

OthIm	Other investments more important
AftRe	Technology can only be implemented after existing technology has been replaced
EnCo	Energy costs are not sufficiently important
LoPrio	Energy efficiency has low priority
CurEf	Current installations are sufficiently efficient
NowIm	Currently introducing the specific technology
Organ	Difficult to implement due to internal organisation
IntBu	Internal constraints on the budget
ExtBu	Problems with external financing
UnQua	Uncertainty regarding the quality
Sub	Better to wait for subsidies
Cheap	Technology will become cheaper
Overv	No good overview of existing technologies
Wait	Better to await experience of colleagues
Norms	Maybe new technology will not satisfy future standards

Table 3b. Barriers for implementation of energy saving technologies: firms' characteristics, simple ordered probit

BARRIERS	Sample average	Energy quote	Investment quote	Profit quote	Size	Competition	International orientation
GENERAL							
OthIm	3.74	+0.32	-0.65	**-7.65*****	**+0.14***	+0.24	+0.01
AftRe	3.51	**-1.17***	+0.14	+2.35	+0.08	+0.05	+0.01
EnCo	3.35	**-1.21***	-0.02	+1.10	+0.04	-0.13	+0.14
LoPrio	3.08	-0.84	+1.17	+0.53	+0.03	-0.04	-0.04
CurEf	3.00	-0.73	+0.54	+2.25	+0.06	-0.26	+0.15
NowIm	2.96	-0.37	+0.74	+3.26	+0.04	+0.13	-0.01
Organ	2.83	**+1.45***	+0.65	-0.46	-0.12	**+0.63****	-0.08
FINANCE							
IntBu	2.66	-0.60	-0.47	+0.28	**+0.17****	+0.11	+0.15
ExtBu	2.22	-0.43	-1.17	+0.27	-0.01	-0.24	-0.09
UNCERTAINTY							
UnQua	2.71	-0.73	+0.39	+2.35	-0.05	+0.18	-0.09
Sub	2.54	-1.31	+0.10	**+7.51*****	-0.03	+0.22	+0.16
Cheap	2.48	-0.80	-0.93	**+4.02****	-0.00	**+0.60****	+0.01
Overv	2.38	-0.96	-0.39	+1.09	-0.04	-0.17	-0.09
Wait	2.35	-0.65	-0.47	**+8.02*****	-0.03	**+0.47***	+0.01
Norms	2.33	-1.91	+0.12	+0.58	+0.03	+0.09	-0.04

*/**/*** indicates significance at the 0.1/0.05/0.01 level (two-sided t-test) in simple ordered probit regression; Bold estimates indicate that sign of significant parameter in simple regression is 'robust': no significant parameter of the opposite sign is found for this variable in multiple regressions

4. Responsiveness to policy changes

Having discussed the investment behaviour of firms, we will now turn to a discussion of policy issues. In this section, we will discuss how firm state they would respond to the introduction of an energy tax. In particular, we asked firms to state the likelihood that they would react to an increase in energy taxes on a national level, with no rebatements of the revenues generated, by: lowering or increasing production, changing the production mix towards less energy intensive goods, charging customers with the increased costs, introduce and adopt energy saving technologies, develop energy saving technologies, change to other energy sources (wind or solar energy), leave the market by either shutting down or evade the tax by moving abroad, or do nothing and accept the loss. In the next section, we will consider the related question on the extent to which firms find particular policies acceptable.

Figure 4 gives some insight into the expected reactions (under the assumption of no rebatements). Firms are likely to react by (faster) introduction of energy saving technologies or charging the customers with the additional costs. Also changes in the product mix are considered as a useful option. Clearly, taxes will not be ineffective; the 'no reaction' option received the lowest score.

< Insert Figure 4 around here >

Tables 4a and 4b yield insights into whether the reactions on an energy tax vary with firm and sector characteristics.

Table 4a. Reactions on introduction of energy tax on national level with no rebatement: sectors, OLS

REACTIONS	Sample average	CHEM	BASEMET	MET	FOOD	PAPER	HORT	REST
AltEn	2.47	-0.51**	-0.01	-0.11	+0.28	-0.47	+0.39*	+0.08
Shut	2.14	+0.19	-0.45	+0.29	+0.05	+0.53	+0.07	-0.44
DevET	2.64	-0.14	+0.36	-0.26	-0.33	-0.22	+0.29	+0.06
ImpET	3.49	-0.31	-0.07	+0.05	+0.32	+0.08	+0.15	-0.14
Price	3.19	-0.41	+0.35	+0.67*	+0.34	+0.52	-0.88***	+0.46
PrMix	2.55	-0.09	+0.07	-0.19	+0.20	-0.12	+0.28	-0.35
Nothing	1.56	+0.05	-0.02	-0.28	-0.06	-0.13	+0.14	+0.04
IncPr	2.39	-0.62***	-0.00	-0.31	+0.02	-0.10	+0.51**	+0.16
DecPr	2.06	+0.65***	+0.10	-0.44	-0.18	+0.44	-0.16	-0.34
Migr	2.60	+0.58**	-0.60	-0.03	-0.60*	+1.40**	+0.23	-0.55*

*/**/*** indicates significance at the 0.1/0.05/0.01 level (two-sided t-test) in OLS regression

VARIABLE DESCRIPTOINS
AltEn   Employ other sources of energy;
Shut   Shutting down;
DevET   Own development of energy saving technologies;
ImpET   Introduce energy saving technologies;
Price   Increase prices of final products;
PrMix   Start producing a less energy intensive product mix;
Nothing No reaction and incur the loss;
IncPr   Increase production;
DecPr   Decrease production;
Migr   Move (parts of) firm to foreign country.

Table 4a reveals that the reactions on the introduction of an energy tax are significantly different from the average reaction in the chemical sector and the horticulture. More

specifically, the employment of alternative energy sources is no viable alternative for the chemical sector, while it certainly is in horticulture. There is a strong tendency in the chemical sector to either decrease production in reaction to the introduction of an energy tax or to evade the tax by moving abroad. In horticulture, charging customers with the costs is no alternative, which can be understood from the fact that firms in this sector are strong price takers, prices being determined on the auction. This price-taking behaviour in the horticulture is further illustrated by the fact that especially in this sector, firms are more strongly inclined to *increase* rather than *decrease* their production after imposition of a tax. For a practical price-taker, a tax means that the profit margin decreases, and a larger turnover is necessary to cover fixed costs.[4] The alternative of moving abroad is also strongly considered in the paper industry. This alternative is not seriously considered by the food industry and the machinery and textiles, which can be understood from the lack of external competitors (see Table 1 and Table 4b).[5]

The results in Table 4b reveal that the responsiveness to an increase in energy taxes is particularly high in competitive industries.[6] The threats from competitors clearly force firms in these industries to react, and the more so the stronger the international orientation. It is interesting to note that more profitable firms have a low tendency to move abroad. This may be explained from the fact that this (probably more drastic) response is not considered necessary when a firm is currently profitable. A related reason could be that current

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[4]   The result that a production *increase* is, in general, considered a more appropriate response to an energy tax than a production *decrease* seems at odds with textbook models of a firm's response to environmental taxation (e.g., Baumol and Oates, 1988). It *could* reflect that firms anticipate a larger equilibrium production level, due to other firms leaving the market. A less academic explanation would be the one given in the main text: firms would have a certain target profit level, and will *try* to sell more after imposition of a tax. This would reflect that firms consciously or unconsciously assume that their average variable costs are constant, and do not consider the fact that higher sales with a given demand curve require lower prices. It would validate the 'folkloristic claims' that firms do not think and act marginally.

[5]   It is interesting to confront the sectoral dependency of the migration-response with the study by van Beers and van den Bergh (1997). They show that the reduction in exports as a consequence of stricter environmental policies is stronger in non-resource based industries than in resource based industries. The fact that the firms that argue to likely react by migrating are located in industries with many foreign competitors may be seen as evidence that these firms are not primarily based in the Netherlands for reasons of resource availability and may thus be seen as an explanation for the fact that especially these firms argue to react by migrating.

[6]   Results on the responsiveness to international increases in energy prices, national energy taxes *with* rebatements, and the imposition of stricter standards are also available.

profitability could partly be explained from a relatively favourable current location, where a firm, for instance, benefits from a successful exploitation of local comparative advantages (labour markets, accessibility, and so forth).

Finally, it is noteworthy that that especially firms with a relatively strong international orientation are hesitant to simply shift the burden from the national energy tax to their customers. This is also conform our prior expectation.

Table 4b. Reactions on introduction of energy tax on national level with no rebatement: firms' characteristics, simple ordered probit

REACTIONS	Sample average	Energy quote	Investment quote	Profit quote	Size	Competition	International orientation
AltEn	2.47	+0.15	-0.48	+0.76	-0.04	+0.07	-0.06
Shut	2.14	+0.29	-0.11	-0.02	+0.03	**+0.28**[*]	+0.10
DevET	2.64	+0.02	+0.36	+0.07	-0.03	+0.10	+0.08
ImpET	3.49	-0.15	+0.56	+0.19	-0.02	+0.04	-0.08
Price	3.19	**-1.90**[*]	-0.56	+0.11	-0.05	-0.09	**-0.23**[***]
PrMix	2.55	+0.19	-0.06	+0.09	-0.01	+0.05	-0.05
Nothing	1.56	+0.53	NA	NA	NA	NA	NA
IncPr	2.39	+0.59	+0.81	-0.13	**-0.15**[***]	-0.17	-0.10
DecPr	2.06	+0.31	-0.03	-0.03	**+0.10**[**]	**+0.37**[**]	**+0.15**[*]
Migr	2.60	+0.37	-0.60	**-2.94**[**]	**+0.21**[***]	**+0.38**[**]	**+0.30**[***]

*/**/*** indicates significance at the 0.1/0.05/0.01 level (two-sided t-test) in simple ordered probit regression; Bold estimates indicate that the sign of a significant parameter in simple regression is 'robust': no significant parameter of the opposite sign is found for this variable in multiple regressions

5. Attitudes Towards Environmental Policy

When barriers are existing and restrain firms from investing, there is a potential role for the government. The barriers found in our survey may provide a justification for the active role the Dutch government has recently played in coping with environmental problems, and the type of actions undertaken. Acceptability and support for the various policy measures are a prerequisite for their success. We have therefore asked firms on their opinion about various types of environmental policy. Figure 5 summarises the main findings. As one would expect, subsidies are preferred to taxes. Voluntary agreements are also appreciated, in contrast to standards. These results reveal that firms want to maximise the freedom in deciding how to

cope with the desire of the government to increase the quality of the environment. Obviously, the acceptance of energy taxes strongly increases if measures are taken that minimise the adverse effects on the firms' competitive position and profitability. Examples are energy taxes with direct recycling of the tax revenues through lower labour taxes, and energy taxes on a European level. Clearly, it is not the efficiency or effectiveness of energy taxes *per se* (the effect on *relative* input prices) that worries firms most, but much more the distributional effect (the money transfer), inducing adverse effects on the competitive position of the firm. This evidence provides rather unambiguous guidelines for improving the acceptability of increasing energy taxes as proposed in the Dutch Environmental Plan (the so called *NMP3*).

< Insert Figure 5 around here >

Another issue in energy policy is whether additional policy measures to reduce energy use are acceptable for firms, or only so under certain conditions. The majority of firms indicated to accept government interference, especially when this is taking place in an international setting. This again points at the importance of taking into account and sustaining the competitive position of firms when judging energy policies.

Finally, we return to the question whether the acceptability of energy policies in general and policy measures in particular did vary between sectors and with firm characteristics. The results are summarised in Tables 5a, 5b, 6a, and 6b.

Table 5a. Acceptation of energy policies in general: sectors, OLS

ACCEPTATION	Sample average	CHEM	BASEMET	MET	FOOD	PAPER	HORT	REST
Acc	2.95	-0.05	+0.13	+0.26	+0.36	+0.05	-0.32	-0.07
AccForm	3.29	+0.36	+0.28	+0.21	+0.31	-0.15	-0.29	-0.51
DaccF	0.48	+0.40	+0.24	-0.35	-0.18	-0.33	+0.00	-0.14
AccSec	3.55	+0.40*	+0.31	-0.17	+0.45	-0.17	-0.20	-0.65**
DaccS	0.69	+0.44*	+0.31	-0.69*	-0.02	-0.44	+0.11	-0.29
AccAbr	3.74	+0.26	+0.12	-0.18	+0.17	-0.11	+0.01	-0.63*
DaccA	0.94	+0.43	+0.06	-0.61	-0.24	-0.44	+0.24	-0.28

*/**/*** indicates significance at the 0.1/0.05/0.01 level (two-sided t-test) in OLS regression

VARIABLE DESCRIPTION

Acc	Acceptable in any case;
AccForm	Acceptable provided policy is in a particular (unspecified) format;
DaccF	Difference between acceptability of policy in particular format and acceptability in any case
AccSec	Acceptable provided policy applies to all sectors;
DAccS	Difference between acceptability of policy applied in all sectors and acceptability in any case
AccAbr	Acceptable provided policy also applies abroad;
DaccA	Difference between acceptability of policy applied abroad and acceptability in any case.

Table 6a. Acceptation of specific types of energy policies: sectors, OLS

ACCEPTATION	Sample average	CHEM	BASEMET	MET	FOOD	PAPER	HORT	REST
TaxNL	2.02	-0.16	+0.28	+0.11	+0.25	+0.08	-0.27	+0.08
TaxNLR	3.01	-0.10	-0.01	+0.13	-0.15	+0.09	-0.27	+0.58**
DtaxNLR	1.03	+0.12	-0.33	-0.03	-0.31	-0.03	-0.06	+0.54*
TaxEU	2.90	+0.02	+0.03	+0.17	-0.15	+0.40	-0.28	+0.21
DtaxEU	0.89	+0.20	-0.27	+0.04	-0.26	+0.31	-0.05	+0.06
StanTec	2.22	-0.04	+0.24	-0.15	+0.34	+0.11	-0.05	-0.28
StanUse	2.31	-0.12	+0.46*	-0.24	+0.16	+0.29	-0.05	-0.20
InvSub	3.43	+0.21	+0.03	+0.17	+0.13	+0.13	-0.33*	-0.03
RDSub	3.49	+0.38*	-0.03	+0.05	+0.07	+0.07	-0.15	-0.29
Volag	3.20	+0.27	+0.30	+0.08	-0.08	-0.20	-0.20	-0.08

*/**/*** indicates significance at the 0.1/0.05/0.01 level (two-sided t-test) in OLS regression

VARIABLE DESCRIPTION

TaxNL	Acceptability of energy tax in Netherlands;
TaxNLR	Acceptability of energy tax in Netherlands with rebatement of tax revenues;
DTaxNLR	Difference in acceptability between energy tax in Netherlands with and without rebatement;
TaxEU	Acceptability of energy tax on European level;
DTaxEU	Difference in acceptability between energy tax in Europe and in Netherlands;
StanTec	Acceptability of technology standards;
StanUse	Acceptability of emission standards;
InvSub	Acceptability of investment subsidies;
RDSub	Acceptability of R&D subsidies;
Volag	Acceptability of voluntary agreements.

We may conclude from Tables 5a and 6a that the acceptability of policy measures is relatively high in the chemical sector and the sector producing basic metals. It is evident from Tables 5b and 6b that this result is likely to be driven by the fact that large internationally operating firms that face strong competition make up these sectors. Acceptability is fairly low in the horticulture, machinery and textile industry, which have characteristics exactly opposite to those of the chemical and basic metals industry. A surprising result is that the acceptability of some policy measures is low for profitable firms. These firms especially oppose against subsidies and voluntary agreements, which may be seen as measures that put relatively weak competitors in a comparatively advantageous position.

Table 5b. Acceptation of energy policies in general: firms' characteristics, simple ordered probit

ACCEPTATION	Sample average	Energy quote	Investment quote	Profit quote	Size	Competition	International orientation
Acc	2.95	-0.25	-0.78	-0.03	+0.06	+0.14	-0.05
AccForm	3.29	+0.10	-0.51	-0.09	**+0.14**[**]	**+0.33**[*]	-0.02
DaccF	0.48	+0.33	+0.20	-0.07	**+0.12**[**]	**+0.32**[*]	+0.09
AccSec	3.55	+0.18	-0.51	-0.06	**+0.16**[***]	+0.28	+0.01
DaccS	0.69	+0.38	+0.34	-0.06	**+0.14**[**]	**+0.41**[**]	+0.12
AccAbr	3.74	+0.01	-0.24	**-2.44**[*]	**+0.17**[***]	**+0.51**[***]	**+0.18**[**]
DaccA	0.94	+0.23	+0.17	-0.03	**+0.14**[***]	**+0.52**[***]	**+0.24**[***]

*/**/*** indicates significance at the 0.1/0.05/0.01 level (two-sided t-test) in simple ordered probit regression; Bold estimates indicate that sign of a significant parameter in simple regression is 'robust': no significant parameter of the opposite sign is found for this variable in multiple regressions

Table 6b. Acceptation of specific types of energy policies: firms' characteristics, simple ordered probit

ACCEPTATION	Sample average	Energy quote	Investment quote	Profit quote	Size	Competition	International orientation
TaxNL	2.02	-0.39	-0.18	+0.01	**-0.11**[**]	-0.15	**-0.15**[*]
TaxNLR	3.01	-0.09	+0.48	+0.01	-0.06	-0.18	-0.09
DtaxNLR	1.03	+0.27	+0.55	-0.01	+0.04	-0.06	+0.03
TaxEU	2.90	-0.46	+0.66	+0.07	-0.03	-0.02	-0.02
DtaxEU	0.89	-0.19	+0.69	+0.08	**+0.08**[*]	+0.14	+0.12
StanTec	2.22	+0.45	-0.13	-0.15	**+0.09**[*]	-0.06	+0.11
StanUse	2.31	+0.17	+0.41	+0.02	**+0.09**[*]	+0.15	+0.06
InvSub	3.43	+0.08	-0.36	**-2.47**[***]	**+0.09**[*]	-0.09	+0.01
RDSub	3.49	+0.50	-0.56	-0.12	**+0.18**[***]	+0.05	**+0.13**[*]
Volag	3.20	+0.37	-0.11	**-3.67**[***]	**+0.26**[***]	+0.02	**+0.15**[**]

*/**/*** indicates significance at the 0.1/0.05/0.01 level (two-sided t-test) in simple ordered probit regression; Bold estimates indicate that sign of a significant parameter in simple regression is 'robust': no significant parameter of the opposite sign is found for this variable in multiple regressions

6. Conclusions

This paper has presented and interpreted the results of a survey among Dutch firms carried out in the context of a nation-wide environmental program on 'Policy Instruments for Energy Efficiency Improvement'. The survey has provided us with a unique data set that to obtain a better understanding of how investment decisions are being made, how they vary between heterogeneous firms and sectors, and how they can potentially be influenced by environmental policy. These insights are important for the development of efficient *and* acceptable environmental policies in a small open economy like the Dutch one.

From our investigation, we may conclude that energy saving increasingly becomes an integrated and normal part of the business operation of Dutch firms. The economic potential for cost savings is the most important driving force behind investment decisions. The existence of other, more attractive, investment opportunities and the uncertainty about potential declines in the price or improvements in the quality of new technologies are important impediments for not (yet) investing in energy saving technologies. A more strict environmental policy is acceptable for many firms, provided that this measure will not negatively affect profitability and the competitive position of firms. Taxes, especially with 'recycling' programmes and carried out in a wider international context, are even preferred by to detailed policy guidelines on how to achieve policy goals.

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Appendix. Description of Variables

ACC	Energy policies acceptable in any case
ACCABR	Energy policies acceptable provided it also applies abroad
ACCFORM	Energy policies acceptable provided it is in a particular (unspecified) format
ACCSEC	Energy policy acceptable provided it applies to all sectors
AFTRE	No adoption because technology can only be implemented after existing technology has been replaced
ALTEN	React on energy tax by employing other sources of energy
BASEMET	Basic metals industry
CHEAP	No adoption because technology will become cheaper
CHEM	Chemical industry
COMP	Degree of competition on sales market (1=limited, 2=average, and 3=strong);
COMPIN	Location of competitors (1=mainly in Netherlands, 2=less than 50% abroad, 3=more than 50% abroad, 4=virtually all abroad).
CUREF	No adoption because current installations are sufficiently efficient
DACCA	Difference between acceptability of policy applied abroad and acceptability in any case
DACCF	Difference between acceptability of policy in particular format and acceptability in any case
DACCS	Difference between acceptability of policy applied in all sectors and acceptability in any case
DECPR	React on energy tax by decreasing production
DEVET	React on energy tax by own development of energy saving technologies
DTAXEU	Difference in acceptability between energy tax in Europe and in Netherlands
DTAXNLR	Difference in acceptability between energy tax in Netherlands with and without rebatement
ENCO	Energy costs are not sufficiently important
ENQ	Energy intensity (expenditures on energy as percentage of sales)
EXTBU	Problems with external financing
FOOD	food industry
HORT	horticulture
IMPET	Introduce energy saving technologies
INCPR	Increase production
INQ	Investment ratio in 1997 (total investments as percentage of sales)
INTBU	Internal constraints on the budget
INVSUB	Acceptability of investment subsidies
KNOW_EXIST	knowledge on already existing technologies that are currently being used by competitors
KNOW_NEW	knowledge on new technologies that are not yet being used in practice.
LABOUR	Number of employees (sum of full time and part time employees)
LLABOUR	Log of number of employees
LOPRIO	Energy efficiency has low priority
MET	metal products industry
MIGR	Move (parts of) firm to foreign country
NORMS	Maybe new technology will not satisfy future standards
NOTHING	No reaction and incur the loss

NOWIM	Currently introducing the specific technology
OBSERV	Number of observations
ORGAN	Difficult to implement due to internal organisation
OTHIM	Other investments more important
OVERV	No good overview of existing technologies
PAPER	paper industry
PRICE	Increase prices of final products
PRMIX	Start producing a less energy intensive product mix
PRQ	Profit ratio (total net profits as percentage of sales)
RDSUB	Acceptability of R&D subsidies
REST	other industries, namely machinery, construction materials and textiles industry.
SHUT	Shutting down
STANTEC	Acceptability of technology standards
STANUSE	Acceptability of emission standards
SUB	Better to wait for subsidies
TAXEU	Acceptability of energy tax on European level
TAXNL	Acceptability of energy tax in Netherlands
TAXNLR	Acceptability of energy tax in Netherlands with rebatement of tax revenues
UNQUA	Uncertainty regarding the quality
VOLAG	Acceptability of voluntary agreements
WAIT	Better to await experience of colleagues

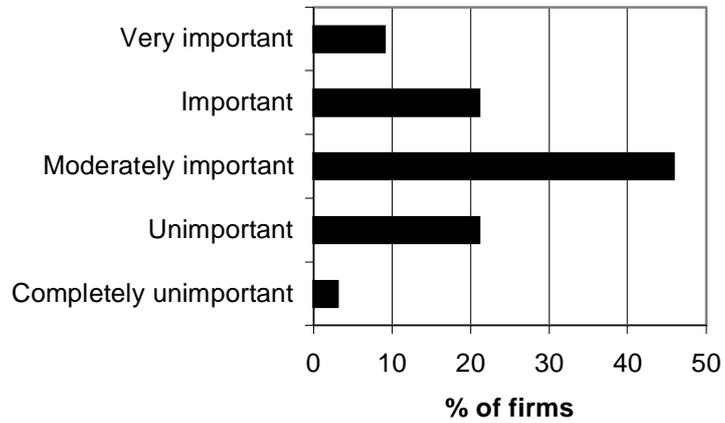**Figure 1. Relative importance of energy efficiency in general investment decisions**

Figure 2. Barriers confronting firms when introducing new technologies

GENERAL

Other investments more important

Technology can only be implemented after existing technology has been replaced

Energy costs are not sufficiently important

Energy efficiency has low priority

Current installations are sufficiently efficient

Currently introducing a new technology

Difficult to implement due to internal organisation

FINANCIAL

Internal constraints on the budget

Problems with external financing

UNCERTAINTY

Uncertainty regarding the quality

Better to wait for subsidies

Technology will become cheaper

No good overview of existing technologies

Better to await experience of colleagues

Maybe new technology will not satisfy future standards
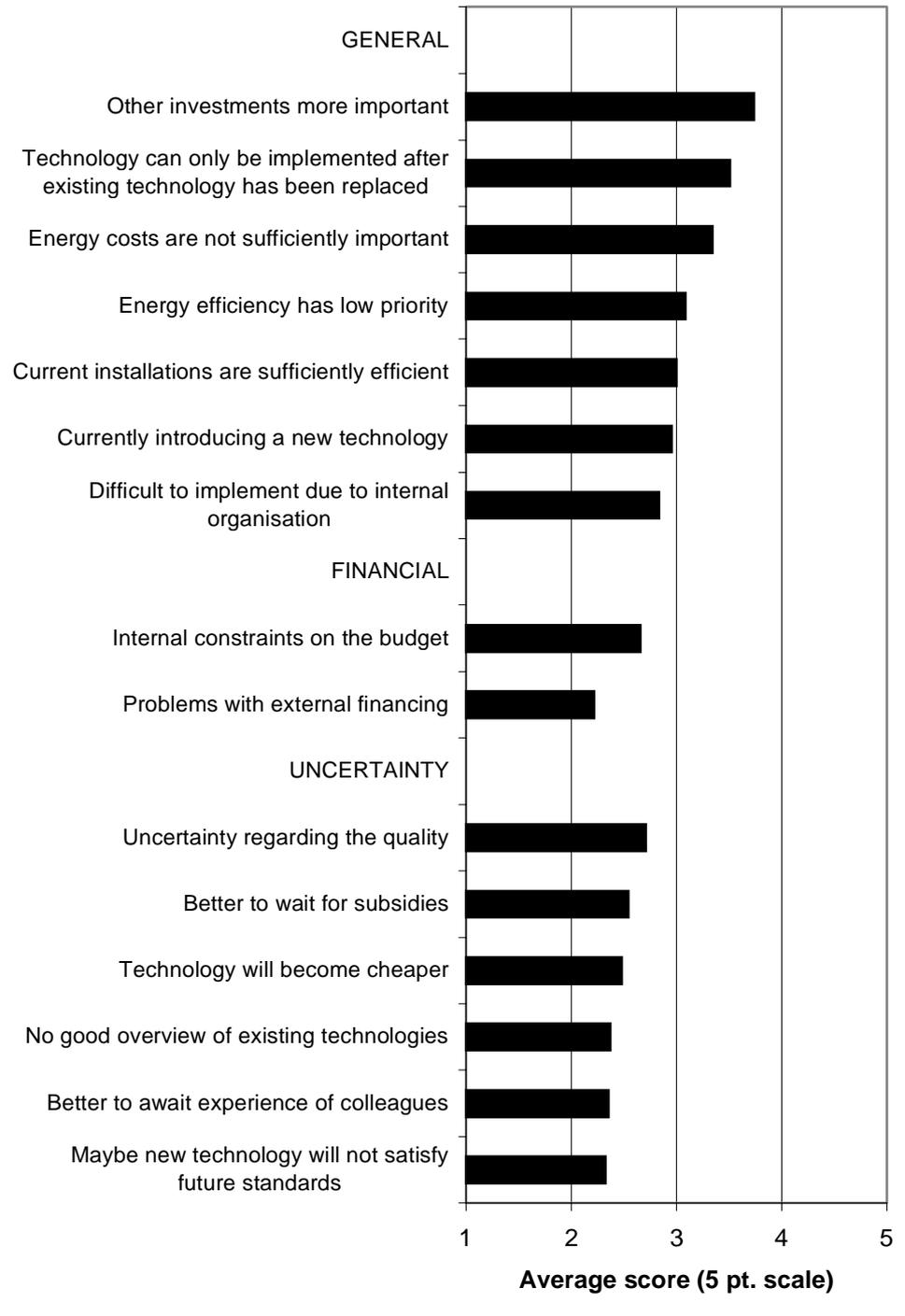
Average score (5 pt. scale)

25

Figure 3. Relative importance of motives in deciding whether to implement new energy saving technologies
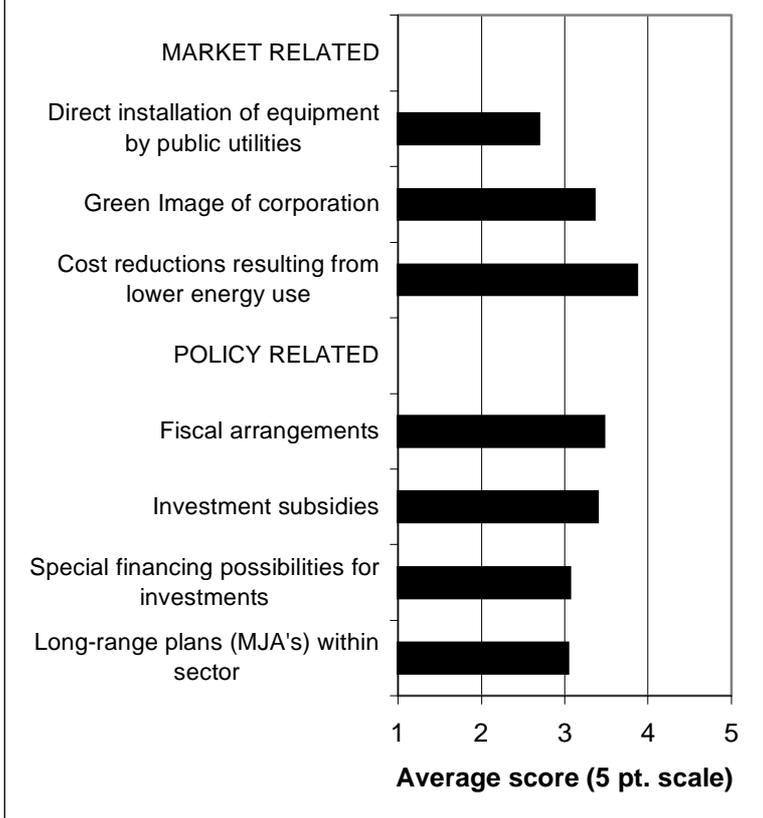
Figure 4. Behavioural response to an increase in national energy taxes with no rebatements

Introduce energy saving technologies

Increase prices of final product

Own development of energy saving technologies

Move (parts of) firm to foreign country

Start producing a less energy intensive product mix

Employ other sources of energy

Increase production

Shutting down

Decrease production
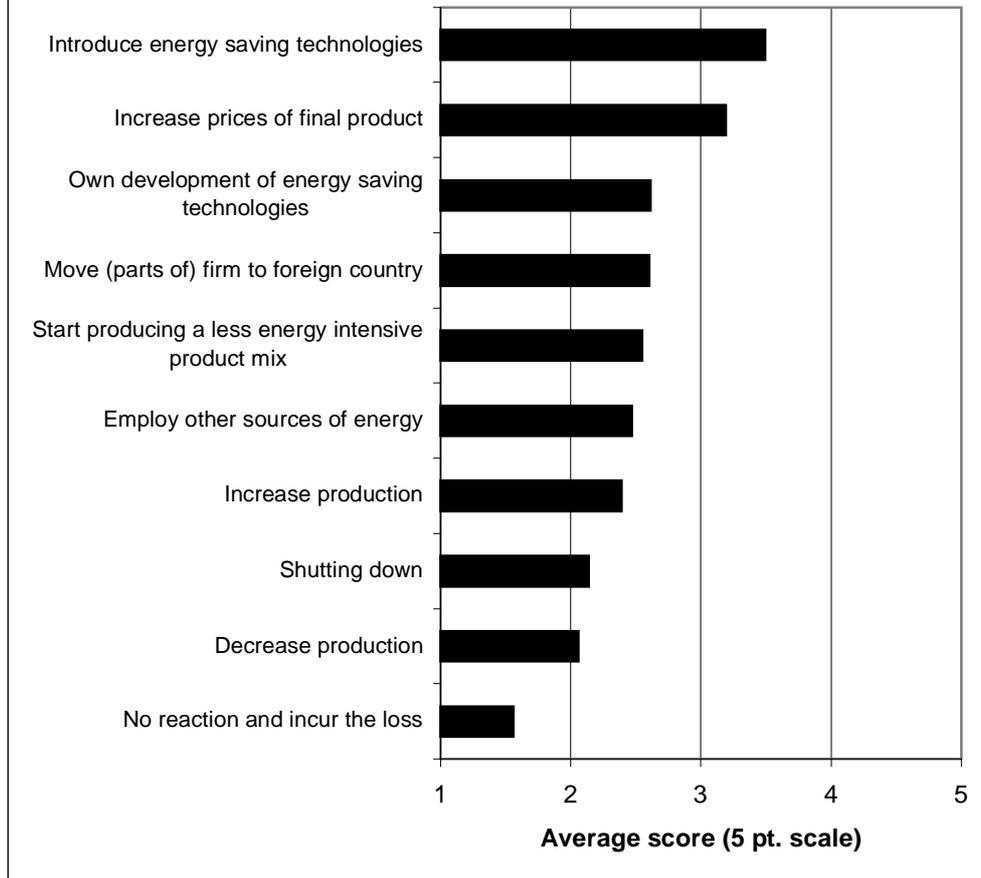
No reaction and incur the loss

Average score (5 pt. scale)

Figure 5. Opinion on environmental policies

Category	Average score (5 pt. scale)
VOLUNTARY AGREEMENTS	
Voluntary agreements	
SUBSIDIES	
Subsidies on R&D	
Investment subsidies	
STANDARDS	
Energy standards: technology standard	
Energy standards: maximum energy use	
TAXES	
Energy taxes on European level	
Energy taxes with complete recycling	
Energy taxes within the Netherlands	