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A comment on the adoption of energy-efficiency-measures within firms - Energy costs and firm heterogeneity

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Zusammenfassung

Es gibt eine Vielzahl von Untersuchungen, die die Determinanten von Energie-Effizienz-Maßnahmen (EEMs) in Firmen, wie zum Beispiel die Höhe der Investitionskosten, die erwartete Kostenersparnis, das verfügbare Know-how und die Firmengröße, analysieren. Statt einer breitangelegten Analyse dieser Art werden in der vorliegenden Studie zwei Teilfragen von hoher wirtschaftspolitischer Relevanz beantwortet. Erstens wird vermutet, dass die Energie-Kostenanteile einen positiven Einfluss auf die Implementierung von EEMs haben. Diese Vermutung ist zwar aus einer betriebswirtschaftlichen Perspektive plausibel, vernachlässigt allerdings grundlegende volkswirtschaftliche Zusammenhänge. Solange ein Mindestmaß an Wettbewerb vorliegt, haben ineffiziente Firmen generell eine geringere Überlebenswahrscheinlichkeit. Der Zusammenhang zwischen Kostenanteilen und der Durchführung von EEMS ist daher wahrscheinlich eher das Resultat sektoraler Unterschiede und nicht das Resultat von Effizienzunterschieden einzelner Firmen innerhalb dieser Sektoren. Zweitens wird gezeigt, dass sich die Determinanten von EEMS in verschiedenen Wirtschaftsbereichen stark voneinander unterscheiden und kaum verallgemeinert werden können.

Abstract

The literature has identified a number of determinants of energy efficiency measures (EEMs) in firms, such as investment costs, expected profitability, the level of information and firm size. Instead of contributing a comprehensive analysis of this sort this paper theoretically and empirically addresses two questions with important policy implications. First, it has been suggested that energy cost shares positively affect the adoption of EEMs. This is plausible from a management perspective but ignores economic reasoning. Inefficient firms will be less likely to survive as long as they face competition. The association most likely reflects sectoral differences rather than differences in individual firm efficiency. Second, I stress the starkly heterogeneous nature of EEM adoption by presenting the differential impact of firm size and energy audits by sector.

Keywords: Energy efficiency, Energy policy, Technological diffusion

JEL Classification: D20, Q48

1. Introduction

The literature on energy efficiency measures (EEMs) in firms is a relatively recent phenomenon. Yet, it has been growing in proportion to the rising academic and policy interest in the topic. One strand within this literature focuses on the quantitative analysis of determinants and obstacles of EEMs (DeCanio and Watkins, 1998; de Groot et al., 2001; Anderson and Newell, 2004 Schleich, 2009; Schleich and Gruber, 2008; Fleiter et al., 2012; MIE, 2014; Schwartz and Braun, 2013; Costa-Campi et al., forthcoming; also see Backlund et al., 2012, and Cagno et al., 2013, for non-empirical contributions). Some findings of this literature start to converge. For example, lacking profitability or information, high investment costs or low priority of EEMS have been found to impede adoption repeatedly (Fleiter et al., 2012; de Groot et al., 2001; MIE, 2014; Schleich, 2009, Schwartz and Braun, 2013). Firm size, on the other hand, was found to have a mixed impact (Fleiter et al., 2012; Anderson and Newell, 2004). This note focusses on two factors that have either been ignored or have not been sufficiently explored in the literature, the effect of energy cost shares and the heterogeneous nature of firms and its effect on EEM adoption.

De Groot et al. (2001, 727) state that EEMs will be adopted if energy costs, and therefore potential savings, are sufficiently high to warrant the attention of managers. In other words, “higher cost shares indicate higher cost-saving potentials and higher economic returns on companies’ effort to surmount the barriers to energy-efficiency” (Fleiter et al., 2012, 873). In accordance with this reasoning, the empirical evidence appears to confirm this association (Fleiter et al., 2012; Groot et al., 2001; Schleich and Gruber, 2008; Schleich, 2009; and Velthuijsen, 1995). While this management/organization perspective is valid, there are a number of unexplored dimensions to this question.

First, even in the absence of rational cost-minimizing managers firms which survive in a competitive environment behave “as if” they were rational (Alchian, 1950). Firms which fall far below the energy efficiency frontier will be forced to exit and remaining firms will be closer to the frontier. Thus, it is unlikely that higher energy cost shares reflect starkly inefficient production methods. Excessively inefficient firms should no longer exist in the market already, unless there is very little competition.

Secondly, the energy cost share *between* sectors reflects differential market conditions and technological requirements. Bakeries for example are more energy intensive than hair dressing salons. On the other hand, the energy cost share difference between firms *within* a certain sector may or may not indicate different degrees of energy efficiency, depending on the heterogeneity of the product or service profile. Some bakeries for example may mill their own flour instead of buying it, as it allows them to provide strictly separated production lines in order to avoid cross contamination of allergens. Within each thusly emerging sub-sector however, individual firm differences in energy cost shares cannot be too pronounced in the presence of market competition.

Thirdly, the empirical results supporting an association between energy cost shares are merely backed by statistical significance alone. None of the authors analyze effects sizes, which may, in fact, be trivial (see Ziliak and McCloskey, 2008). Below, I will analyze energy survey data (ZDH-energy-survey) based on more than 4,000 small and medium sized businesses, collected by the German Confederation of Skilled Crafts (ZDH[1]), all of whom belong to the German occupational legal category of ‘Handwerk’ (skilled crafts[2]). It will be shown that, while the association between energy cost shares and EEMs is statistically significant in many specifications none of them are economically significant. In fact, effects sizes are small enough to be irrelevant.

Another dimension of EEM adoption has not been given due attention. Firms in different sectors of the economy face vastly dissimilar technological and market conditions. In fact, these conditions may amount to very specific determinants and barriers of EEM adoption. As to date, only three studies that I am aware of include sector information (de Groot et al., 2001, and Schleich, 2009, Costa-Campi et al., forthcoming), of which only Schleich (2009) has a sufficient number of cases to be usefully exploited. The author indicates that results from his multiple sector models “yield a more heterogeneous picture. The numbers and types of relevant barriers vary across sub-sectors, and most sub-sectors are subject to relatively few of the barriers explored” (Schleich, 2009, 2158).

By using the sector information in the ZDH-energy-survey, firm heterogeneity can be illustrated. Firm heterogeneity should have a particularly strong effect on the effectiveness of energy audits. Homogeneous firms do not have large search costs when it comes to finding energy savings potentials, whereas heterogeneity renders a one-size-fits-all audit approach impossible. The results of the ZDH-energy-survey suggest that a firm’s participation in an energy audit program induces either a large impetus in terms of EEM adoption or none at all, depending on the sector.

The remainder of the paper is structured as follows. Section two summarizes the main characteristics of the data set and the empirical methods employed. Section three presents the results. Section four summarizes my findings and discusses academic and policy implications.

2. Data and Methods

The ZDH-energy-survey was conducted in early 2012 as a part of the semi-annual general business survey. There are about 5,300 responses from across Germany. These firms collectively employ about 88,700 individuals (mean per firm<20) within 39 occupational categories[3]. The data is collected by the ZDH, the German Confederation of Skilled Crafts, a federal interest group organization which seeks to politically represent about one million firms that belong to more than 90 occupations, which, in turn, are legally classified in the German Trade and Crafts Code (HwO).

The data set contains information on specific energy usage by source (electricity, gasoline, etc.). However, neither do managers/company owners[4] always know these figures nor do they take the time to collect this information before filling in the survey. Instead, I have used energy costs for the three sub-sectors of electricity, heating and fuel (transportation), which

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1 Zentralverband des Deutschen Handwerks

2 The skilled crafts are comprised of more than 90 occupations which are specified in German Trade and Crafts Code (HwO).

3 See table two for all occupational categories.

4 The roles of company owner and manager commonly coincide in small firms.

are relevant for the business owner and therefore cognitively available. Proceeding this way, a total energy cost variable can be generated for 4,400 firms.

Missing answers for any of the three energy cost categories may reflect zero energy cost or ignorance on the part of the company owner (also see DeCanio and Watkins, 1998, for solutions to this problem). In order to distinguish between these cases I have cleaned the data in a five step procedure. Subsequently, I cross validated the cleaned data. First, If electricity usage is greater than zero but companies failed to report electricity cost, the sample mean price of 22.7 cent/k was applied in order generate a cost estimate (n=331).

Second, there are 48 cases for which heating costs but no electricity costs are available. This situation indicates missing responses. A workspace that requires heating typically goes along with electricity costs as well, unless the firm generates their own electricity via photovoltaic at zero marginal cost. In fact, nine of the 48 cases generate renewable energy. The remaining 38 cases were dropped.

Third, there are 594 observations with information on electricity cost but no information on heating cost. This situation could occur if an electric heater is utilized. They might also use solar heat, biomass heat, a thermal heat pump etc. It turns out there are 173 legitimate such cases. 395 cases were dropped that contained electricity cost information, no heating cost information, no fuel cost information and did not rely on their own source of renewable heating.

Fourth, there are 175 cases that contain only fuel costs. After inspection, these cases were deemed legitimate. All of them are service oriented occupations, such as hairdressers or painters. Most of them are one-man-businesses, which have been shown to lack a separate company site in two out of three cases (Müller and Vogt, 2014). They either operate out of their homes or work at the premises of their customers. Larger companies that provided nothing but fuel cost were dropped (n=40). Finally, 542 firms did not provide any energy cost information whatsoever and were removed from the sample.

In order to cross validate the resulting cleaned sample, I compare the mean total energy costs of companies with complete energy cost information (electricity, heat, and fuel) with the mean total energy costs of all companies. This procedure was carried out for several occupations with a sufficiently large sample size. The energy cost gap ranges from 5 to 11 percent. However, an error of 5-11 percent is unlikely. The total energy costs of firms with complete energy cost information *overestimates* actual mean energy costs. It is, for example, quite plausible that some bakeries or carpenters simply do not have fuel costs. The estimated error must be regarded as an unlikely upper bound and the data set is deemed to be reliable for further analysis.

The data contains 14 categories of EEMs that have either been implemented or not. A factor analysis (principal components) was performed on these variables. The factor analysis is based on a polychoric correlation matrix because Pearson-correlations are not suitable for binary variables. The varimax-rotation yields four components with an eigenvalue greater than 1 (confirmed by a scree plot). The 14 variables reduce to the four factors building, cross-sectional technologies, electricity- and heat generation, and transportation (see table 1). The four factors explain more than 62 percent of the overall variation. The Kaiser-Meyer-Olkin-Test yields a value of 0.55. Thus, the 14 variables can be used in a factor analysis.

Table 1: Results of Factor Analysis for Implemented Energy Efficiency Measures

Factor Name	Explained Variance	Factor-Loadings of individual EEM variables
Building	21.2%	insulation wall (0.85), roof (0.81) and basement (0.84), new windows (0.79), heating/ hot water (0.48)
Cross-Sectional Technology	17.5%	air compression (0.79), ventilation/ cooling (0.74), lighting (0.6), wasteheat utilization (0.78)
Electricity- and Heat generation	13.6%	combined heat/power (0.9), electricity (0.76), other (0.61)
Transportation	10.26%	new vehicles (0.8), efficient route planning (0.73)

A linear probability model is utilized. The binary dependent variable measures whether or not one or more EEMs were adopted in the last five years. Consequently, this specification does not capture the intensity of EEMs. Therefore, an unreported specification uses the dependent variable 'number of EEMs' instead. This, however, does not affect my key results even though, of course, coefficients themselves change. Similarly, obtaining marginal effects after logit estimation yield almost identical figures as OLS.

$$EEM = \alpha + \beta * X_i + \gamma * G_j + \varepsilon$$

The following explanatory (X_i) variables are used. Total energy cost is represented by energy cost as a fraction of total revenue and energy cost per employee. The latter variable is a measure of absolute energy cost, the former is, perhaps, more relevant for internal business decisions. However, it is also more sensitive to the value of inputs. Respondents are reluctant to reveal revenue information, which is why there are only half as many observations in this specification. However, the choice of energy cost variable does not affect coefficients significantly, even though I do not always report results for both 'energy cost/ revenue' and 'energy cost/ employees'. Additionally, 'size' signifies the number of employees (plain and squared); there is a dummy $(G_j)$for each occupational category except optician (occupation fixed effects), a region (east, west) and energy audit dummy, an interaction term for audit and firm size, and a variable indicating if special entry requirements apply[5].

All regression results are weighted in order to correct for response bias, i.e. larger firms are more likely to respond to surveys than smaller ones. I am using weights based on six firm size (number of employees) categories in each of the 39 occupational categories. Weights were generated by comparing firm size distributions in the ZDH-energy-survey with data on the skilled crafts sector collected by the Federal Office of Statistics ('Handwerkszählung 2011'), resulting in 234 individual weights.

5 Some occupational categories in the skilled crafts sector require an advanced vocational training degree in order to open a business (annex A vs. B of the Trade and Crafts Code). The dummy turned out insignificant in all specifications, which is why it was removed in the second regression results table.

3. Results

Table two displays regression results for each of the EEM categories identified by the factor analysis. While more energy intensive sectors are much more likely to implement EEMs (see coefficients for the baker, butcher and brewer dummy) than others (scaffolders, road workers, opticians etc.) energy cost within a sector does not have an important impact. Energy cost is statistically significant or close to being statistically significant in the EEM category building and cross-sectional technologies. However, effect sizes are negligible, i.e. an increase in energy cost per employee of 1,000 Euros increases the likelihood of implementing a single EEM by only one percent or less. To put these numbers in perspective, the mean annual energy cost per employee of a bakery, an energy intensive sector, is about € 3,400. A photographer, optician or dental technician (low energy intensity) only pays € 2,200. Thus, while there are stark differences in EEM implementation between occupational sectors energy cost within an occupational sectors does not affect EEM implementation.

I have run the regressions in table two with an alternate explanatory variable: 'energy cost/ revenue'. The coefficients across the four categories amount to 0.01 (buildings) and zero for cross-sectional technologies, electricity and heat generation, and transportation - therefore confirming our finding above. Energy costs do not affect EEM adoption.

The positive impact of firm size is not surprising. It captures economies of scale in the implementation of EEMs, such as lower search costs and the ability of intra firm division of labor, as well as lower transaction costs, such as credit constraints, which have been discussed in the literature (see Fleiter et al., 2012, Schleich and Gruber, 2008, Mai et al., 2014, and others). The positive marginal impact of size continues until a firm size of about 172[6], after which it turns negative (diseconomies of scale). The size variable, however, cannot be fruitfully interpreted because it also captures the following simple statistical property: The probability of modernizing a roof of firm A, which owns of two buildings, is twice as high as the same probability of firm B, with only one building.

There is a strongly positive and statistically significant association between audit and EEM implementation. Again, the interpretability of this result is hampered by possible reverse causality. This problem becomes especially pronounced for the EEM category building. In order to receive government subsidies for modernizing a building an audit is required. However, even excluding the EEM category building, the effect ranges from 3 percent (electricity and heat) to 14 percent (transportation).

The positive coefficient of the interaction term 'audit*size' suggests that, for the EEM category building, smaller firms are more likely to implement an EEM than larger firms if an energy audit has been performed - again pointing to well-known transaction cost effects - where smaller companies suffer higher search costs, and thus, benefit more from audit information.

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6 Equation for the point of inflection: $= \frac{b1}{2xb2} = \frac{0,0031}{2x\ 5,41\text{x}10^{-6}}$, where the coefficients are taken from an unreported specification across all four EEM categories.

Table 2: EEM adoption by EEM category - weighted Linear Probability Model

	building		**cross-sectional technology**		**electricity- and heat generation**		**transportation**	
Dep. Variable: One or more EEMs implemented	*coeff.*	*p*	*coeff.*	*p*	*coeff.*	*p*	*coeff.*	*p*
energy cost/ employee (in €1,000 increments)	0,01	0,12	0,00	0,06	0,00	0,98	0,00	0,27
size (increments of 100)	0,17	0,00	0,33	0,00	0,11	0,00	0,25	0,00
$size^2$	0,00	0,04	0,00	0,00	0,00	0,00	0,00	0,00
audit	0,19	0,00	0,10	0,00	0,03	0,02	0,14	0,00
audit * size (increments of 100)	-0,14	0,01	0,02	0,76	0,02	0,58	-0,05	0,42
entry restriction	-0,08	0,44	0,07	0,46	-0,12	0,12	-0,04	0,63
estern Germany	0,01	0,57	0,00	0,87	-0,03	0,00	0,04	0,02
occupations								
optician	-	-	-	-	-	-	-	-
baker	0,31	0,00	0,10	0,16	0,01	0,66	0,19	0,00
brewer	0,30	0,04	0,38	0,01	0,01	0,96	0,38	0,00
butcher	0,24	0,00	0,06	0,45	0,11	0,00	0,15	0,01
orthopaedic shoemaker	0,23	0,06	0,05	0,66	-0,01	0,53	0,19	0,09
plumber	0,22	0,02	-0,14	0,06	-0,01	0,81	0,20	0,01
carpenter	0,22	0,00	-0,03	0,61	0,00	0,84	0,25	0,00
confectioner	0,21	0,08	0,02	0,89	-0,02	0,27	0,02	0,78
agricultural machinery mechanic	0,18	0,12	-0,18	0,01	0,03	0,41	0,12	0,19
installer and heating contractor	0,18	0,01	-0,08	0,25	0,05	0,04	0,23	0,00
car mechanic	0,17	0,01	-0,04	0,52	0,01	0,55	0,07	0,15
painter and varnisher	0,15	0,03	-0,13	0,05	0,02	0,35	0,20	0,00
refrigateration mechanic	0,14	0,22	0,04	0,71	0,04	0,42	0,32	0,01
metal worker	0,14	0,04	-0,12	0,08	0,02	0,40	0,19	0,00
roofer	0,13	0,05	-0,17	0,01	0,03	0,30	0,18	0,00
plasterer/ stuccoer	0,13	0,21	-0,14	0,10	-0,04	0,06	0,10	0,24
electric technician	0,13	0,04	-0,07	0,26	0,05	0,03	0,21	0,00
precision machinist	0,12	0,10	-0,07	0,34	0,02	0,38	0,13	0,04
information technician	0,12	0,19	-0,05	0,59	0,05	0,29	0,22	0,01
vehicle body maker	0,11	0,21	-0,10	0,20	0,00	0,85	0,03	0,69
electrical engineer	0,11	0,31	-0,06	0,56	-0,03	0,19	0,14	0,14
textile cleaner	0,11	0,55	0,19	0,23	-0,06	0,62	0,14	0,35
hair dresser	0,11	0,11	-0,11	0,09	-0,01	0,70	-0,01	0,87
orthopaedic technician	0,10	0,46	-0,18	0,11	0,05	0,57	0,08	0,51
joiner	0,08	0,23	-0,14	0,04	0,05	0,10	0,17	0,00
glazier	0,07	0,41	-0,10	0,21	0,00	0,89	0,13	0,09
bricklayer and concrete worker	0,07	0,29	-0,18	0,01	0,02	0,31	0,16	0,00
galvanizer/ electrplater	0,06	0,68	0,12	0,35	-0,01	0,96	0,03	0,82
interior decorator	0,05	0,64	0,05	0,56	-0,11	0,16	0,18	0,05
R2	5,15%		8,75%		3,9%		5,06%	
N	4.181		4.181		4.181		4.181	

Note: Shoemakers, tailors, cosmetologists/beauticians, photographers, dental technicians, floor tilers, vulcanizers are not significantly more or less likely to implements EEMs than opticians. Building cleaners, scaffolders, manufacturers of sign and light advertising, road builders are significantly less likely to implement EEMs than opticians.

Table three displays results for eight distinct occupations, using either ‘energy cost/ revenue’ (upper table) or ‘energy cost/ employee’ (below). Again, while the variable ‘energy cost/ revenue’ is highly statistically significant in six out of eight occupations, effect sizes are very small. A ten percent increase in energy cost/ revenue increase the likelihood of implementing an EEM by one percent or less. To put this in perspective, in the data set, mean energy costs over revenue (by occupation) range from three to eight percent, thus, a 10 percent increase represents more than twice the common energy costs over revenue for most firms. Alternatively, ‘energy cost/ employee’ is only significant for the occupation of bricklayer and concrete worker and the effect size is small.

Finally, I would like to point to the highly variable impact of a number of determinants. An energy audit increases the likelihood of implementing an EEM by 21 to 38 percent (upper table) or 16 to 42 percent (lower table). If one includes the occupation of carpenters or installers and heating contractors, there seems to be no significant effect at all, which cannot be explained by insufficient number of observations. Similarly, the size variable affects each occupation quite differently. While there seems to be little or no effect for the occupation of baker or bricklayer and concrete worker, firm size positively and strongly affects EEM implementation for the occupational sectors installer and heating contractor, and, to a lesser extent, electrical technician.

Table 3: EEM adoption across occupational categories - weighted Linear Probability Model

Dep. Variable: One or more EEMs implemented	**electrical technician**		**installer and heating contractor**		**car mechanic**		**bricklayer and concrete worker**		**carpenter**		**metall worker**		**painter and varnisher**		**baker**	
	coeff.	*p*	*coeff.*	*p*	*coeff.*	*p*	*coeff.*	*p*	*coeff.*	*p*	*coeff.*	*p*	*coeff.*	*p*	*coeff.*	*p*
energy cost/ revenue *(10% increments)*	0,01	0,00	0,01	0,57	0,00	0,00	0,03	0,39	0,00	0,00	0,00	0,00	0,01	0,01	-0,03	0,87
size *(increments of 10)*	0,11	0,00	0,28	0,06	0,05	0,21	0,01	0,07	0,06	0,44	0,06	0,88	0,13	0,35	-0,01	0,72
size²	0,00	0,00	0,00	0,10	0,00	0,71	0,00	0,75	0,00	0,65	0,00	0,18	0,00	0,40	0,00	0,87
audit	0,33	0,00	0,21	0,27	0,21	0,05	0,38	0,01	0,34	0,00	0,31	0,03	0,32	0,12	0,21	0,05
audit * employees *(increments of 10)*	-0,04	0,25	-0,03	0,02	0,00	0,44	0,00	0,90	-0,01	0,03	-0,04	0,18	-0,01	0,74	0,00	0,67
eastern Germany	-0,12	0,10	0,08	0,42	0,09	0,25	-0,02	0,82	0,13	0,23	0,08	0,47	0,07	0,48	-0,07	0,45
R2	11,73%		3,56%		5,73%		6,77%		4,60%		5,90%		5,66%		5,60%	
N	202		147		184		204		157		141		118		112	

Dep. Variable: One or more EEMs implemented	**electrical technician**		**installer and heating contractor**		**car mechanic**		**bricklayer and concrete worker**		**carpenter**		**metall worker**		**painter and varnisher**		**baker**	
	coeff.	*p*	*coeff.*	*p*	*coeff.*	*p*	*coeff.*	*p*	*coeff.*	*p*	*coeff.*	*p*	*coeff.*	*p*	*coeff.*	*p*
energy cost/ employee (€1,000 increments)	0,01	0,46	0,01	0,21	0,00	0,59	0,02	0,04	0,01	0,70	0,01	0,33	0,01	0,48	0,00	0,49
size *(increments of 10)*	0,07	0,00	0,17	0,01	0,05	0,01	0,02	0,30	0,11	0,04	0,04	0,10	0,16	0,14	0,00	0,80
size²	0,00	0,04	0,00	0,04	0,00	0,00	0,00	0,95	0,00	0,14	0,00	0,32	0,00	0,19	0,00	0,92
audit	0,25	0,00	0,18	0,13	0,16	0,05	0,42	0,00	0,03	0,86	0,23	0,02	0,28	0,11	0,25	0,00
audit * employees *(increments of 10)*	0,01	0,77	-0,14	0,02	0,00	0,91	-0,04	0,00	-0,01	0,83	-0,03	0,20	-0,03	0,87	0,00	0,79
eastern Germany	-0,05	0,39	0,06	0,36	0,18	0,00	-0,01	0,82	-0,01	0,91	0,12	0,10	0,01	0,95	-0,10	0,18
R2	5,67%		6,99%		6,47%		8,30%		1,58%		4,72%		4,36%		7,55%	
N	397		292		413		375		310		248		201		172	

4. Summary and Implications

This article has pointed toward two underappreciated and underexplored issues in the quantitative literature on EEM adoption. First, while a positive effect of energy cost shares on EEM adoption is plausible from a managerial perspective, market competition will also force highly inefficient companies to exit the market - and only those closer to the cost-minimizing frontier remain.

Differential energy costs can be the result of operating in different market segments. Thus including sector fixed effects in regressions is paramount but may actually not sufficiently capture the heterogeneity of markets. Two bakeries may yet bear different energy costs when they display diverse product and service profiles.

The previous literature failed to highlight effect sizes of the energy-share variable and merely noted a statistically significant association. While this paper has confirmed the statistically significant impact, actual effect sizes are close to zero, supporting selection effect of market competition.

Secondly, this paper has highlighted the highly heterogeneous nature of EEM implementation in different occupational sectors. Due to different technological conditions and energy requirement, EEM implementation is given a differential priority rating in each sector. Similarly, firm size and energy audits have quite diverse effects on EEM implementation in each sector.

The findings of this paper have implication for both future research and economic policy. First, it appears to be desirable to always include sector specific effects in future regression analysis, although this might actually not be sufficient to capture heterogeneous technology and market conditions. Alternatively, industry and sector specific studies should be performed as each of these heterogeneous areas are likely governed by highly idiosyncratic factors. Secondly, effect sizes ought to be reported in order to distinguish between mere statistical and economic significance. Thirdly, in regard to the current focus on energy audits by policy makers (e.g. in Germany), a careful consideration should be given to the possibility of industry and sector specific audits. A one-size-fits-all audit approach might be within the limits of what is politically feasible. However, the complexities of business heterogeneity likely exceed the planning capabilities of policy makers. It is conceivable that auditors should be regulated less and given more space to specialize in order to provide advice suitable to the context-specific environment of each technological and market sector.

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