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Sied Hassen, Tagel Gebrehiwot, and Tiruwork Arega

Abstract

We conducted a cross-sectional survey of 8174 micro, small and medium enterprises from ten major urban areas in Ethiopia to study the determinants of the enterprises' adoption of energy efficiency practices and technologies. For identification, we rely on a generalized ordered probit model. The findings reveal that, as the size of the enterprise becomes larger, it is more likely the enterprise will undertake energy efficient practices and technologies. This may be because larger enterprises are less likely to face constraints related to capital or know-how to adopt these technologies. Further, enterprises which are clustered in an industrial zone are also more likely to use energy efficient technologies, revealing a spillover effect of being located in the same place. Enterprises with highly educated entrepreneurs are in favor of the adoption of the technologies. By contrast, entrepreneurs who perceive pro-environmental activities as unnecessary and costly are less likely to use energy efficient technologies. Our results imply that expansion of industrial zones and educational (informational) campaigns are important for enhancing micro and small enterprises' adoption of energy efficient technologies.

Key Words: energy efficiency, enterprise, enterprise size, generalized ordered probit

JEL Codes: D00, D21, Q40

Contents

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1. Introduction

The Ethiopian economy has been on a continuous growth trajectory since 2003/04, registering average annual growth of 10.6% between then and 2015/16 (EEA, 2015). The industrial sector grew by more than 10% annually averaged over the same period (EEA, 2015). The Ethiopian industrial sector is dominated by micro, small and medium scale enterprises (MSMEs). MSMEs make a significant contribution to the economic growth of developing countries (Keskin et al., 2010). In Ethiopia, MSMEs are the second largest employer, following the agricultural sector, providing jobs for around 50% of the urban labor force (Kellow et al., 2010). Against this background, the government has paid significant attention to the role of MSMEs and has designed policies to promote their development. The 2003 industrial development strategy and the second Growth and Transformation Plan (GTP II) indicated MSMEs as one of the priority sectors for government direct support.

Manufacturing processes of micro, small and medium enterprises are energy intensive (Nagesha, 2008). MSMEs are the leading consumers of energy next to the residential sector (Karekezi, 2002; Karekezi and Kithyoma, 2002; Hillary, 2004; Swan and Ugursal, 2009; Cagno and Trianni, 2013; Never, 2016). They generally are less energy efficient than large enterprises; as a result, rapid growth of the sector puts pressure on the energy sector (Mulugetta, 2008; Cagno et al., 2010; Bazilian et al., 2011). Accordingly, meeting the high demand for energy in the MSME sector is a prominent challenge in developing countries (Armaroli and Balzani, 2007; Brew-Hammond, 2010; Bhattacharya et al., 2012).

In addition, MSM enterprises are prone to creating negative social and environmental externalities, some of which are closely linked to the utilization of energy (Nagesha and Balachandra, 2006; Omoruyi and Dhurup, 2015). More efficient energy use keeps the level of greenhouse gas (GHG) emission low (Fleiter et al., 2012) and this is one of the main options for

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achieving sustainable development (Jochem, 2000). In this regard, reducing energy waste and energy consumption through adoption of energy efficient technologies in this sector should be seen as a strategy that policy-makers can use to achieve energy efficiency targets.

Improved energy efficiency could improve enterprises' competitiveness by minimizing production costs (Cantore et al., 2016; Li and Lin, 2016). However, companies often fail to implement energy efficiency measures despite a positive rate of return. A recent baseline study by the Environment and Climate Research Center (ECRC) at the Ethiopian Development Research Institute (EDRI) indicated that 69% of the surveyed MSMEs do not have measures in place to conserve energy and resources. This signifies that adopting energy efficiency measures is not a particularly high priority, although these measures would be cost-effective from the enterprise's perspective. In order to promote the most effective policies to enhance MSMEs' energy efficiency, it is vital to fully understand the barriers with respect to energy efficiency and the factors that limit enterprises from using energy efficient technologies.

There is growing evidence on the barriers to enterprises' adoption of energy efficiency measures. However, many of the studies are either from developed countries or transitional economies (Harris et al., 2000; Nagesha and Balachandra, 2006; Fleiter et al., 2012; Trianni and Cagno, 2012; Cagno and Trianni, 2013; Kostka et al., 2013; Trianni et al., 2013a; Trianni et al., 2013b). There are few studies in sub-Saharan African countries (e.g., Never, 2016). Except Never (2016), the existing empirical evidence from Africa is either based on qualitative study or does not look at the energy efficiency aspect of the enterprises. To the best of our knowledge, in Ethiopia there is a dearth of evidence on the barriers to the adoption of energy efficient practices. Therefore, filling this gap and obtaining a better understanding of the barriers to MSMEs' energy efficiency is important in its own right. Thus, the question of why enterprises in Ethiopia fail to undertake energy efficiency investments motivates this study.

Using cross-sectional data on 8174 micro and small enterprises, collected from 10 major urban areas in Ethiopia, we find that, as the size of the enterprise becomes larger, it is more likely that the enterprise undertakes energy efficient practices and investments. This is because larger enterprises are less likely to face constraints related to capital or know-how to adopt these technologies. It could also be because larger firms have larger cost saving potential than smaller firms. Further, our results indicate that enterprises that engaged in metal or woodwork activities are more likely than other types of enterprises to adopt energy efficient machinery. This is because these enterprises use light machinery, which can be replaced sooner with energy efficient machinery at lower cost, compared to enterprises that use heavy machinery. We also found that clustered enterprises (i.e., industries located in industrial zones) are more likely to adopt energy efficient technologies, showing a neighborhood effect. However, entrepreneurs who perceived that pro-environmental activities are unnecessary and costly are less likely to use energy efficient technologies.

The paper is structured as follows. The next section gives a brief review of the literature. We then discuss the empirical approach or identification strategy used, the study setting and the data, and descriptive results. Finally, we present the empirical results and discussion, followed by the conclusion.

2. Literature Review

In what follows, we present a brief review of the studies focused on the reasons that enterprises fail to adopt energy efficiency measures that would reduce their costs and thereby improve their competitiveness.

Kostka et al., (2013) studied barriers to small-and-medium sized enterprises' (SME) energy efficiency investments. Their findings indicate that only a minority of SMEs in China actively perform energy saving activities at a significant level. Further, the study indicates that informational barriers are the core bottleneck constraining energy efficiency improvements in China's SME sector.

Trianni and Cagno (2012) found that the major barriers limiting the SME sector from investing in energy efficiency interventions were access to capital; lack of (or imperfect) information on cost-efficient energy efficiency interventions; less know-how on energy efficiency practices; and the form in which information was available. Concomitant with this, Harris et al. (2000) reported that firms did not carry out cost-effective energy efficiency measures because managers are often unaware of relevant technologies and information on energy efficiency measures is not available; thus, the potential energy savings remain unknown.

Nagesha and Balachandra (2006) found financial and economic barriers and behavioral and personal barriers as the top two impediments to energy efficiency improvements in India's small-scale industries. However, Trianni et al. (2013b) found the lack of interest in energy efficiency and the existence of other priorities as the most relevant barriers to the adoption of energy efficient technologies, thus showing that decision-makers tend to downgrade energy efficiency to a marginal issue. In another study, Trianni et al. (2013a) investigated the barriers to energy efficiency in SMEs and found that the greatest barriers are the perception of the lack of financial resources to be devoted to improving energy efficiency, and the existence of other priorities such as the importance of guaranteeing business continuity (i.e., staying in business). Similarly, Never (2016) found that behavioral barriers impeded energy efficiency, which contributed to the limited performance of MSEs in Uganda. Limited self-control and short-term thinking, habits, a status quo bias and a lack of trust impede the uptake of energy efficiency, while first-hand experience with efficient technology, implementation or intention to implement, and social learning can be conducive.

Fleiter et al. (2012) investigated the factors driving the adoption of energy efficiency measures by small and medium-sized enterprises (SMEs) and found high investment costs as the major impediment to the adoption of energy efficient measures. Similarly, Cagno and Trianni (2013) reported the importance of public financing for energy efficiency interventions, as well as the importance of external pressures such as increases in energy prices and the introduction or increasing of fees on both resources consumed and on emissions of pollutants. The presence of people with great ambition and entrepreneurial minds within the company is important for the adoption of energy efficient technologies.

From the above review, we found that most of the existing empirical evidence is in the context of developed and transitional economies, except for a few studies in Sub-Saharan Africa. To the best of our knowledge, there is no study in Ethiopia on the barriers that MSMEs face in the adoption of energy efficient practices and technologies.

3. Empirical Approach

The energy efficient technologies we considered in this study are energy efficient machinery (energy star machinery) and energy efficient light bulbs.[1] Using these two technologies, we generate an ordinal rank of enterprises' use of the technologies. The rank is based on the number of types of energy efficient technologies the enterprise adopted. The higher the number, the more likely the enterprise is to save a higher quantity of energy. This means an enterprise that does not use any energy efficient technology will have the lowest rank; an enterprise that uses both technologies will have the highest rank. Considering this, an ordered discrete choice framework is used in this study. Thus, given this ordinal nature of enterprises' adoption of energy efficient technologies and assuming that individual enterprises' adoption is based on the latent variable (K_i^*), the ordered response model can be written as

$$K_i^* = x_i{}'\beta + \varepsilon_i, \varepsilon_i \quad N(0,1) \tag{1}$$

$$K_i = j \text{ if } \eta_{j-1} < K_i^* < \eta_j \text{ for j=0, 1, 2...J and } \eta_{-1} = -\infty, \eta_J = +\infty \tag{2}$$

[1] The enterprises covered in the survey are enterprises which are engaged in production activivies. Service enterprises such as restaurants, hotels, and retailers are not included in the survey. Because of this, we only ask these enterprises about the adoption of these two technolgies, because these are the most common types of energy technologies in the sector.

where K_i represents the observed enterprise *i*'s use of energy efficient technologies, which can be ordered according to the number of energy efficient technologies that the enterprise adopted (e.g., K=0 if no energy efficient technology is used, K=1 if either energy efficient bulbs or machinery is used, and K=2 if both energy efficient technologies are used). Further, x denotes the vector of explanatory variables, which includes both entrepreneur and enterprise characteristics and other variables. β is parameter estimates for explanatory variables and η represents an unknown threshold value to be estimated. ε is unobserved error, assumed to be normally distributed with zero mean and variance of one. Conditional on x_i, the standard ordered probit model can be written as:

$$P(K_i = j \mid x_i) = \Phi(\eta_j - x_i^{'}\beta) - \Phi(\eta_{j-1} - x_i^{'}\beta) \text{ for j=0,1,2...J} \quad (3)$$

where Φ is the standard normal cumulative distribution function, with $\Phi(\eta_{-1} = 0)$ and $\Phi(\eta_J = 1)$. This standard ordered probit model can be estimated using the maximum likelihood method of estimation.

However, the standard ordered probit models implicitly impose the parallel regression assumption. This implies a homogeneous effect of the explanatory variables across the cumulative distribution of the energy efficient technologies, i.e., a single crossing of marginal probability effects or constant relative effects (Maddala, 1983; Boes and Winkelmann, 2005; Zhang and Hassen, 2017). To relax this rather restrictive assumption, we can employ a more flexible framework through a generalized ordered probit model, where the effects of explanatory variables such as enterprise size across the cumulative distribution of the dependent variable are unrestricted (Boes and Winkelmann, 2005). This can be carried out by making the threshold values linear functions of the explanatory variables, i.e., $\eta_{ij} = \theta_j + x_i^{'}\lambda_j$ (Lerza, 1985; Zhang and Hassen, 2017). Substituting $\eta_{ij} = \theta_j + x_i^{'}\lambda_j$ in Equation (3) gives the following generalized ordered probit model:

$$P(K_i = j \mid x_i) = \Phi(\theta_j - x_i^{'}\beta_j) - \Phi(\theta_{j-1} - x_i^{'}\beta_j) \text{ for j=0,1,2...J} \quad (4)$$

where the estimated coefficients are $\beta_j = \beta - \lambda_j$. From this we can see that, in the generalized model, the vector of parameters is category-specific. The standard ordered probit model can be treated as a special case of generalized ordered probit model with the imposition of the restriction $\beta_1 = \beta_2 ... = \beta_J$. The generalized ordered probit model can also be estimated using the maximum likelihood method of estimation using the *goprobi*t Stata code.

4. Study Area and Data

The study was conducted in 10 major cities of Ethiopia, namely Adama, Addis Ababa, Bahir Dar, Dessie, Dire Dawa, Gondar, Hawassa, Jigjiga, Jimma and Mekelle, which represent a majority of enterprises in the country. Adama, Bahir Dar, Mekelle, Hawassa and Jigjiga are major cities in the Oromiya, Amhara, Tigray, Southern Nations and Nationalities, and Somalia regions, respectively. Addis Ababa and Dire Dawa are city administrations, while Dessie, Gondar and Jimma are zonal capitals in the Amhara and Oromiya regions.

Primary data from 8174 micro, small and medium sized enterprises were collected from the 10 cities. To obtain the required data, a stratified sampling technique was used. The strata we considered were the major regional cities and 10 sub-cities in the Addis Ababa city administration. Sample size was determined proportional to the size of micro, small and medium enterprise in all regional cities and Addis Ababa. Finally, simple random sampling was employed to select representative sample enterprises. At the end, a total of 8174 enterprises were selected, of which 3310, 4553 and 311 were respectively micro, small and medium sized enterprises.

Three teams were involved in the survey: two coordinators, seven supervisors and 42 enumerators. Appropriate training was given to the team about the entire survey procedure, the objective of the survey and how to approach the respondents. Finally, face to face interviews between data collectors and sample enterprises were conducted. The survey addressed different issues related to enterprises, such as firm and entrepreneurial characteristics, risk and time preference, business profile, finance and investment, business practices, innovation, employment, earnings, occupational safety, and greening. Greening data was related to energy consumption, efficiency and conservation behavior, as well as general enterprise and entrepreneur characteristics.

5. Descriptive Statistics

In this section, descriptive statistics of enterprise and entrepreneur characteristics are presented. The enterprise characteristics include the enterprise's use of electricity for its business operation, use of energy efficient technologies, age of the enterprise, size of the enterprise, type of the enterprise, whether the enterprise is cooperative or non-cooperative, and whether the enterprise is located in a cluster (industrial zone) or not. The entrepreneur characteristics include age, gender, education level and belief in pro-environmental activities. Table 1 shows the descriptive statistics of these characteristics of enterprises and entrepreneurs.

Starting with the enterprise characteristics, from Table 1, we can see that about 95% of the enterprises use mainly electricity for their business operation. This implies that adoption of energy efficient machinery and bulbs would have significant implications for their cost of production and in reducing the growing demand for electricity in the country. In relation to this, only 26% of the enterprises use energy efficient machinery, indicating a significant amount of electricity is being lost because of inefficient technologies. In fact, in a result not shown here, we found that enterprises that use energy inefficient machinery spend about 800 ETB per month more for electricity than those that use energy efficient machinery. Thus, more work is needed to encourage the majority of the enterprises to adopt energy efficient technologies and practices.

By contrast, from Table 1, one can observe that about 80% of the enterprises use energy efficient light bulbs. This could be because the replacement cost is not large compared to the replacement of machinery. Further, such a high rate of adoption of energy efficient bulbs is due to the government's restrictions on the import of energy inefficient bulbs, though there are domestic factories that manufacture both types of bulbs.

Table 1 shows that about 40%, 56% and 14% of the enterprises covered in the survey are micro, small and medium enterprises, respectively, indicating a majority of the enterprises are micro and small enterprises. Disaggregating the adoption of energy efficient technologies across micro, small and medium enterprises, it can be observed that a larger number of medium enterprises than micro and small enterprises adopt both types of energy efficient technology (Table 2).

About 14% percent of the businesses are owned by cooperatives and 45% of them engage in metal and woodwork activities, which are considered light manufacturing, and require relatively less capital. Further, only 20% of the enterprises are located in a cluster or industrial zone. Usually medium and heavy industries tend to be attracted to locating in cluster or industrial zones.

Looking at the entrepreneur characteristics, on average the entrepreneurs are young (about 38 years of old) and dominated by male entrepreneurs (about 81% are male). The average schooling is 11 years, meaning that, on average, the entrepreneurs are neither college nor technical and vocational (TVET) graduates. This implies that the majority of the enterprises are operated by those who did not pass the general graduation examination in 10th grade.

From Table 1, we can also observe that about 15% of the entrepreneurs believe that pro-environmental activities such as adoption of energy efficient technologies are unnecessary and costly. Looking at these characteristics of the entrepreneur across micro, small and medium enterprises, there is no large difference in such negative beliefs about pro-environmental activities (Table 2).

6. Econometrics Results

Results from the maximum likelihood estimation of the generalized ordered probit (GOPROBIT) and standard probit models are presented in Table 3. To control for the effect of location of the enterprises on their choice and adoption of energy efficient technologies, we include city dummies in all the regressions. From Table 3 (Columns 1-4), it can be seen that, in the generalized model, two parameter-vectors (β_1 and β_2) are estimated. The parameter vector β_1 refers to estimated coefficients of the determinants of the enterprise's adoption of either energy efficient machinery or bulbs compared to the base category (never adopted or used energy efficient machinery or bulbs). Vector β_2 is for the adoption and use of both energy efficient technologies. The explanatory variables used in all these regressions are displayed in Table 1. The marginal effects of the variables from generalized ordered probit and standard probit models are presented in Table 4.

The parallel regression assumption, discussed above, implies homogeneous effects of the explanatory variables across the cumulative distribution of three states of adoption of energy efficient technologies (never use, adopt either of the two technologies, adopt both technologies). One way of testing for the parallel regression assumption is by comparing the size and signs of the estimated coefficients in the generalized regression model. From Table 3 (Columns 1-4), we can see some differences in the magnitude of the estimated coefficients for some of the explanatory variables across the categories. For instance, the coefficient of the variable "the enterprise is engaged in metal or woodwork" is insignificant for the use of one of the two technologies (β_1) but significant for the use of both technologies (β_2). From Table 4, we can see that the sign of the marginal effect of the aforementioned variable is negative for the state of using neither technology but is positive for the use of both technologies. This indicates that the parallel regression assumption of the standard ordered probit model may not hold in our context.

A more formal test for this assumption is done using the Wald test. An overall Wald test on the generalized ordered probit model against the standard model also suggests that we can reject the parallel regression assumption (χ^2_{19} =350.61 p-value=0.000). In addition, following Pfarr et al. (2010), a Wald test is applied on each variable to identify which variables have heterogeneous distributional impacts. As can be seen in Table 5, the null hypothesis of equal coefficients can be rejected for 11 out of the 20 variables (including city dummies) at the 5% level of significance. Considering this, we refer to the generalized ordered probit result (GOPROBIT) (Table 3) and its marginal effect results (Table 4).

From the regression results, it is evident that enterprise size, enterprise type, being located in a cluster area, education and environmental attitude of the entrepreneur, and city dummy variables play an important role in determining enterprises' adoption of energy efficient technologies in urban Ethiopia. Beginning our analysis with the size of the enterprises, one can see from Table 3 that the two dummy variables representing small and medium scale enterprises are positive in the two parameter-vectors (β_1 and β_2) of GOPROBIT columns. Likewise, the marginal effect of these two dummy variables is positive for the probability of choosing either or both technologies, when evaluated at the sample mean. These two positive estimates convey the message that, as the size of the enterprise becomes larger, it is more likely that the enterprise adopts either or both of the two technologies. This is because larger enterprises are less likely to face constraints related to capital or know-how. Further, as can be seen from Table 4, the marginal probability effect of small and medium scale on the choice of energy inefficient machinery or bulbs is negative and statistically significant. In general, small and medium scale enterprises are 2.2% and 20.3% more likely than micro enterprises to adopt both energy efficient technologies. The general finding that larger enterprises are more likely to adopt energy efficient technology is consistent with the findings from earlier studies (Anderson and Newell, 2004). However, there are other studies which found an insignificant effect of enterprise size (Fleiter et al. 2012). Fleiter et al. (2012) argued that the insignificant effect could be related to their small sample size or small sample variation.

Being located in a cluster area is also found to be important in determining adoption of energy efficient technologies. As we can see from the results of GOPROBIT in Table 3 and the corresponding marginal effects (Table 4), enterprises located in cluster areas or industrial zones are more likely to adopt either or both technologies. This can be related to the learning or spillover effect. Because of the geographical proximity of enterprises, enterprises that have not adopted energy efficient technology can learn from enterprises that have adopted such technology. They can learn about the benefits and costs, as well as where the technology can be found, and can see the competitive advantage of neighboring enterprises that have adopted efficient technologies. The marginal effect results show that clustered enterprises are 2.7% more likely than non-clustered enterprises to adopt both energy efficient technologies.

Our results also indicate that enterprises that engage in metal or woodwork businesses are more likely to adopt energy efficient technologies, compared to other enterprise types. As shown in Table 3, the GOPROBIT result is positive and significant for the adoption of both technologies but insignificant for adoption of either of the two technologies. This implies that the results in both columns could be influenced by the effect of one of the two technologies. In order to assess this, we run two probit regressions: one for adoption of energy efficient bulbs and one for adoption of energy efficient machinery. The results of the probit regressions are shown in Table 3 (Columns 5-8). The probit results show that there is no significant difference in the adoption of energy efficient bulbs between enterprises that are engaged in metal or woodwork and other types of enterprises. However, there is a significant difference in the adoption of energy efficient machinery. This could be because, compared to other types of enterprises, metal and woodwork enterprises use light machinery, and these machines are more likely to wear out sooner. Thus, they can be replaced sooner with a new one that is energy efficient, because the replacement cost is not that large compared to the replacement of heavy machinery. The marginal effect of the probit regression (in Table 4) shows that enterprises that engaged in metal or woodwork are about 2% more likely to adopt energy efficient machinery than are other enterprise types.

In addition to the enterprises' characteristics, we find that entrepreneur characteristics are important determinants of adoption of energy efficient technologies. Education is an important policy tool to raise entrepreneurs' awareness about the benefits of adoption of energy efficient technologies. This implies that an entrepreneur with a higher education level is expected to be more likely to choose and adopt energy efficient technologies. Our result indicates that a higher education level is a significant determinant of adoption of the technologies. A one percentage point increase in years of education increases the adoption of either of the technologies by 0.6% and both technologies by 0.8% (Table 4). In relation to this finding, entrepreneurs' belief about pro-environmental activities is also a significant determinant of adoption of energy efficient technologies. Those who believe that pro-environmental activities are unnecessary and costly are less likely to adopt energy efficient technologies. According to EaPGREEN (2015), there is a widespread misconception among micro and small enterprises that protecting the environment is associated with cost and burdens.

7. Conclusions

Small and micro enterprises play a large role in the Ethiopian economy, particularly for reducing urban unemployment. The rapid growth of these enterprises and their increasing energy demand put pressure on the energy sector. Meeting the high demand for energy in the MSME sector is a prominent challenge in developing countries, including Ethiopia. To satisfy the growing demand, minimize energy waste and ensure energy efficiency requires an urgent response from all stakeholders. One way of managing the growing energy demand in the country is through the adoption of energy efficient technologies.

There is insufficient evidence about the determinants of enterprises' adoption of energy efficient technologies in sub-Saharan African countries such as Ethiopia. This study attempts to identify the factors that influence enterprise use of energy efficient technologies.

In this study, we used cross-sectional data of 8174 enterprises collected from 10 major urban areas of the country. This data is representative of micro, small and medium sized enterprises in urban Ethiopia. A generalized ordered probit model was used to identify the determinant factors for usage of energy efficient technologies. The results from the generalized ordered probit model show that, as the size of the enterprise becomes larger, it is more likely that the enterprise adopts energy efficient machinery, bulbs, or both. This is because larger enterprises are less likely to face constraints related to capital or know-how to adopt these energy efficient technologies. Likewise, enterprises that engage in metal or woodwork are more likely than other types of enterprises to adopt energy efficient machinery. This is because these enterprises use light machines, which can be replaced sooner and at lower cost, compared to the costs faced by enterprises that use heavy machinery.

The results also show that location in an industrial zone and the educational level of the enterprise owner significantly and positively influence enterprises' use of energy efficient technologies. Further, entrepreneurs' belief about pro-environmental activities is found to be a significant determinant of adoption of energy efficient technologies. Those who believe pro-environmental activities are unnecessary and costly are less likely to adopt energy efficient technologies. However, the age of the entrepreneur, gender of the entrepreneur, operation of the enterprise by cooperatives, and the age of the enterprise were found to be insignificant in both models.

Based on these findings, we draw the following policy implications. First, the low adoption rate of energy efficient machinery implies that the government should not only focus on the income and employment opportunities provided by micro and small enterprises but also on their energy management, including adoption of energy efficient technologies. For this purpose, the government should expand its energy audit program to micro and small enterprises too. Currently the government's energy audit program focuses on only a few selected heavy industries and selected buildings. Second, the government should expand industrial development zones or clusters to include newly-established enterprises. Third, information (educational) campaigns are important to increase awareness on the private and public benefits of adopting energy efficient technologies and practices. Last but not least, in order to increase the adoption rate of energy efficient machinery, enterprises should be given incentives to purchase energy efficient machinery. Incentives such as removing the VAT or reducing the import tax on energy efficient machinery should be considered.

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Tables

Table 1. Descriptive Statistics of Enterprises' and Owners' Characteristics

Variables	Mean	SE
Enterprise Characteristics		
Electricity is mainly used for the enterprise activity (1=yes, 0=no)	0.95	0.22
Use efficient bulb (1 if yes, 0 otherwise)	0.808	0.394
Use energy efficient machinery (1 if yes, 0 otherwise)	0.262	0.440
Use energy efficient bulb and machinery (1 if yes, 0 otherwise)	0.234	0.423
Age of the enterprise (years)	6.059	5.458
Enterprise size-micro (1 if micro, 0 otherwise)	0.400	0.491
Enterprise size-small (1 if small, 0 otherwise)	0.560	0.495
Enterprise size-medium (1 if medium, 0 otherwise)	0.040	0.196
If the enterprise is cooperative (1 if cooperative, 0 otherwise)	0.144	0.351
If the enterprise is engaged in metal or wood (1 if involved in metal/wood work, 0 otherwise)	0.446	0.497
If the enterprise is in industrial zone (1 if located in industrial zone, 0 otherwise)	0.202	0.401
Entrepreneur Characteristics		
Age of the entrepreneur (years)	37.826	10.270
Gender of the entrepreneur (1 if male, 0 otherwise)	0.81	0.39
Education level of the entrepreneur (years of schooling)	11.051	5.541
Belief that pro-environmental activity is unnecessary and costly (1 if yes, 0 otherwise)	0.15	0.360
Observations	8,174	

Table 2. Enterprises' Use of Energy Efficient Technologies and Owners' Beliefs about Pro-Environmental Activities

	Micro	Small	Medium
Use efficient bulb	75%	81%	87%
Use energy efficient machinery	24%	26%	44%
Use energy efficient bulb and machinery	18%	21%	39%
Belief pro-environmental activity is unnecessary and costly	14%	16%	19%
Observations	3310	4553	311

Table 3. Generalized Ordered Probit (GOPROBIT) and Probit Regression of Determinants of Enterprises' Use of Energy Efficient Technologies

	GOPROBIT				Probit regression			
	Either Machinery or bulb		Both Machinery and bulb		Machinery		bulb	
Variables	β_1	SE	β_2	SE	Coef.	SE	Coef.	SE
Age of the enterprise	0.004	0.004	0.001	0.003	0.000	0.003	0.003	0.003
Enterprise size-small	0.110***	0.039	0.078**	0.036	0.028	0.036	0.193***	0.036
Enterprise size-medium	0.352***	0.110	0.593***	0.082	0.506***	0.083	0.418***	0.099
If the enterprise is cooperative	0.011	0.053	-0.016	0.048	-0.007	0.049	0.040	0.049
If the enterprise is engaged in metal or wood	0.030	0.038	0.105***	0.035	0.059*	0.035	0.036	0.035
If the enterprise is in industrial zone	0.145***	0.048	0.093**	0.041	0.118***	0.041	0.006	0.042
Age of the entrepreneur	0.000	0.002	-0.002	0.002	-0.002	0.002	-0.002	0.002
Gender of the entrepreneur	0.033	0.048	-0.008	0.044	-0.005	0.044	-0.021	0.043
Education level of the entrepreneur	0.010***	0.003	0.028***	0.004	0.028***	0.004	0.011***	0.003
Belief that pro-environmental activity is unnecessary and costly	-0.538***	0.045	-0.152***	0.047	-0.091**	0.045	-0.507***	0.043
City dummies	Yes		Yes		Yes		Yes	
Constant	2.685***	0.379	-0.730***	0.134	-0.590***	0.135	1.924***	0.183
Observations	7,887		7,887		7,443		8,152	

Sources: own estimate

Table 4. Marginal Effect for Generalized Ordered Probit and Probit Regression of Determinants of Enterprises' Use of Energy Efficient Technologies

Variables	GOPROBIT						Probit model			
	None		Either		Both		Only Machinery		Only Bulb	
	Coef.	SE	Coef	SE	Coef	SE	Coef	SE	Coef	SE
Age of the enterprise	-0.001	0.001	0.000	0.001	0.000	0.001	0.001	0.001	0.001	0.001
Size of the enterprise-small	-0.024***	0.009	0.002	0.012	0.022**	0.010	0.009	0.012	0.054***	0.01
Size of the enterprise-medium	-0.064***	0.016	0.139***	0.032	0.203***	0.032	0.182***	0.032	0.096***	0.018
If the enterprise is cooperative	-0.002	0.012	0.007	0.016	-0.005	0.014	-0.002	0.015	0.011	0.013
If the enterprise engaged metal or wood	-0.007	0.008	0.024**	0.012	0.030***	0.010	0.019*	0.011	0.01	0.01
If the enterprise is in industrial zone	-0.030***	0.010	0.003	0.014	0.027**	0.012	0.038***	0.014	0.002	0.012
Age of the entrepreneur	-0.000	0.000	0.001	0.001	-0.001	0.001	-0.001	0.001	-0.001	0
Gender of the entrepreneur	-0.007	0.011	0.010	0.015	-0.002	0.013	-0.002	0.014	-0.006	0.012
Educational level of the entrepreneur	-0.002***	0.001	0.006***	0.001	0.008***	0.001	0.009***	0.001	0.003***	0.001
Belief that pro-environmental activity is unnecessary and costly	0.142***	0.014	-0.101***	0.016	-0.042***	0.012	-0.028**	0.014	-0.160***	0.015
city dummy	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	7,887		7,887		7,887		7,443		8,152	

Table 5. 5% Wald Test Result of the Parallel Regression Assumption

Variable	P-value
Age of the enterprise	0.55
Size of the enterprise-small	0.47
Size of the enterprise-medium	0.08*
If the enterprise is cooperative	0.65
If the enterprise engaged metal or wood	0.08*
If the enterprise is in industrial zone	0.19
Age of the entrepreneur	0.18
Gender of the entrepreneur	0.48
Educational level of the entrepreneur	0.000***
Belief that pro-environmental activity is unnecessary and costly	0.000***
All city dummy (C2_C9)	
C2	0.001***
C3	0.000***
C4	0.000***
C5	0.041**
C6	0.000***
C7	0.002***
C8	0.000***
C9	0.000***
C10	0.003***