



# Determinants of enterprises use of energy efficient technologies: Evidence from urban Ethiopia<sup>☆</sup>

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## ABSTRACT

In this paper, we examine the determinants of Micro, Small and Medium Enterprises' adoption of energy efficiency practices and technologies, using cross-sectional data of 8174 randomly selected enterprises from ten major urban areas of Ethiopia. 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, clustered enterprises are also more likely to use energy efficient technologies, revealing spillover effect of being located in the same place or it may reflect entrepreneurs' predisposition towards efficiency. 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 (clusters) to newly established enterprises may help in increasing adoption of energy efficient technologies. Further, informational (educational) campaigns about the private and public (environmental) benefits of energy efficient technologies are also important.

## 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 (MSME). MSMEs make a significant contribution to the economic growth of developing countries. 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 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 cost (Gujba et al., 2012; 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

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(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, 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. 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. Further, clustered enterprises are more likely to use energy efficient technologies, revealing a spillover effect of being located in the same place. By contrast, 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 preasons of why enterprises fail to adopt energy efficiency measures that would reduce their costs and thereby improve their competitiveness.

Micro and small enterprises are typically reliant vulnerable to market shifts. The need to maintain profitability and competitiveness with limited resources can make it more difficult for SMEs to pay attention to energy efficiency and business improvement initiatives. The 2015 International Energy Agency report indicates the most prominent barriers to energy efficiency in SMEs are: limited information on energy efficiency improvement opportunities; limited in-house skills and expertise to identify and implement projects; difficulty accessing the capital to finance energy efficiency improvements (IEA, 2015). Sherriff (2013) argued barriers not only purely technical and economic, but also social and cultural: that is expectations, conventions and decision-making processes will play roles alongside costs and practicalities.

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. They also found that for the small/medium group, barriers relating to a lack of time, lack of internal technical skills and technical challenges associated with energy efficiency improvements were significantly greater compared to the medium/large group. In addition, the small/medium group had lower levels of awareness of energy efficiency. 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-efficient measures is not available; thus, the potential energy savings remain unknown. BMG Research (2009) undertook interviews with 2001 businesses in the North West of England with the aim of understanding attitudes to resource efficiency. A total of 46% respondents revealed barriers to increasing resource efficiency improvements, with the most common reasons for lack of action being a lack of capital/money (15%), perceived cost of making change (14%) and a lack of time to make the changes (4%).

Backman (2017) investigated the existence of different barriers to the implementation of energy efficiency Swedish municipalities. He found that the major explanatory factors related to non-implementation of cost-effective energy efficiency measures among micro- and small-sized industrial enterprises were bounded rationality (lack of time and/or other priorities), split incentives (having other priorities for capital investments), and imperfect information (slim organization and lack of technical skill). Thollander et al. (2007) confirmed the low priority of energy efficiency issues as a major barrier for SMEs of Sweden in energy efficiency measures in over the past 15 years. Kounetas et al. (2011) revealed that the information barrier is the major obstacle restricting companies from adopting energy efficiency technologies in Europe.

Ndichu et al. (2015) investigated the uptake of energy efficiency measures in the cassava- and maize-processing industries in Nigeria and Kenya. They found that about 81% of respondents claimed that high cost of finance was the main barrier to the adoption of energy efficiency measures in Nigeria; about 61% claimed that the lack of support or government incentives as a restraining factor, while 56.5% of respondents reported lack of information on appropriate energy efficiency measures as an obstacle to energy efficiency adoption. Like in Nigeria, the high cost of finance was also observed as the main deterrent factor in Kenya, cited by 50% of the firms interviewed. Lack of information on what the appropriate technologies or measures would be was another deterrent mentioned by 20% of firms. Other factors preventing the adoption of energy efficiency measures, albeit to a lesser extent; include lack of government incentives and poor technical capabilities.

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,

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