Environment for Development

RESEARCH BRIEF

February 2025

Women Empowerment in Energy Efficiency, Innovation and Manufacturing Productivity

Selamawit G. Kebede (PhD)[1], Laura N.Barasa (PhD), Frank Adusah-Poku (PhD), Mawunyo P. Agradi (PhD)

This research brief is based on the EfD Discussion Paper entitled as "Energy Efficiency, Innovation and Productivity of Female-Owned Enterprises in Selected East and Wes[2]t African Countries".

The study highlights the relationship between innovation and energy efficiency and examines how energy efficiency affects the total factor productivity (TFP) in manufacturing enterprises. It also explores how these effects vary in women-owned enterprises in the case of Ethiopia, Kenya, Ghana and Nigeria.

This research sets out the following specific *research questions* focusing on the case study countries:

(1) What is the role of innovation in the energy efficiency of manufacturing enterprises?

(2) What is the role of energy efficiency in manufacturing enterprise productivity?

(3) What is the pattern of energy efficiency, innovation, and productivity for female-owned manufacturing enterprises?

[1] Selamawit is the Principal Investigator (PI) from EfD Ethiopia, Laura, EfD Kenya, Frank and Mawunyo, EfD Ghana.

[2] https://www.efdinitiative.org/news/study-explores-innovation-energy-efficiency-and-productivity-female-led-businesses
https://www.efdinitiative.org/research/projects/energy-efficiency-innovation-and-productivity-female-owned-enterprises-selected

Key Messages

- **It is highlighted that product innovation has a positive effect on energy efficiency**
- **Energy efficiency in the case studies has a positive effect on TFP, capital productivity, and labour productivity**
- **On average, Ghana has the highest energy efficiency among the four studied countries, which include Ethiopia, Kenya and Nigeria**
- **There is no relationship between a firm's level of innovation and the owner's gender in Ethiopia, Kenya, Ghana and Nigeria**
- **Findings highlighted that the productivity effects of energy efficiency are lower for women-owned enterprises**
- **Both labour and capital have positive and significant effects on firm value added, with labour being more elastic than capital**

Background and Methodology

East and West African sub-regions have experienced strong economic growth over the last decade largely driven by growing trade, tourism, increased infrastructural investment and rising gas and oil production (AfDB, 2023b). Despite the importance of the industrial sector in output growth and employment, the sector's contribution has been the least of the three main sectors of the economy and even declined in Nigeria between 2005 and 2022. Furthermore, the manufacturing sector comprises various sub-sectors, such as food processing and textile and wearing apparel, which are often dominated by women-owned enterprises. This implies that the output of these sub-sectors could also be on the decline with dire implications for gender equality as gendered income gaps are more likely to widen and the survival of women-owned enterprises becomes less likely.

In addition, energy deficits, erratic supply, and consequent energy cost challenges affect enterprises in general. Yet, many manufacturing activities often require a high energy supply. For instance, whereas the manufacturing sub-sector in Kenya and Ghana is the largest consumer of the industrial sector's total energy (Ototo, 2022; Macharia et. al., 2022; GoG, 2022), the energy needs of the manufacturing sector could not be met in Ethiopia and Nigeria. Overcoming the energy challenges would require that enterprises be innovative and adopt energy efficiency strategies to reduce the high energy consumption of the manufacturing sector.

While the case countries have introduced various policy measures aimed at firm performance through infrastructural development, access to finance among others, the performance of the manufacturing sector remains low. This necessitates an investigation into the drivers of the manufacturing sector's productivity. In addition, it is important to investigate the extent to which innovation and energy efficiency levels in women-owned enterprises influence productivity and the overall contribution to the manufacturing sector.

This study uses a two-stage approach, with the first stage estimating energy efficiency using a Stochastic Frontier Analysis (SFA) model. The dependent variable includes firm annual value added adjusted for the cost of power outages. The independent variables include factor inputs of labour and capital, energy efficiency-related variables such as power outage frequency, the share of electricity from a generator, and firm capacity, and control variables such as ownership structure, export orientation, and firm size. The study adopts a translog model specification to capture the non-linearities in the production function.

The second stage of the analysis uses the predicted energy efficiency scores from the first stage SFA regression as the dependent variable and firm innovation including product and process innovation as the chief independent variable. Independent variables include capital input, raw material input, top manager experience, gender indicators, and firm size. The study also controls for country and year heterogeneities. This study uses the Crépon Duguet, and Mairesse (1998) i.e., CDM model to study the relationship between energy efficiency, innovation, and productivity at the firm level.

Results

The study had three main objectives: (1) to examine the effect of innovation on energy efficiency, (2) to examine the effect of energy efficiency on productivity, measured by capital and labour, and (3) to examine the gender patterns of innovation, energy efficiency, and productivity. A visual presentation of the distributions of the firm-level technical energy efficiency coefficients is given in figure 1 below. On average, firms in Ghana show the highest energy efficiency (92%) among the four case study countries. The other three

have similar levels of energy efficiency levels hovering below 80%.

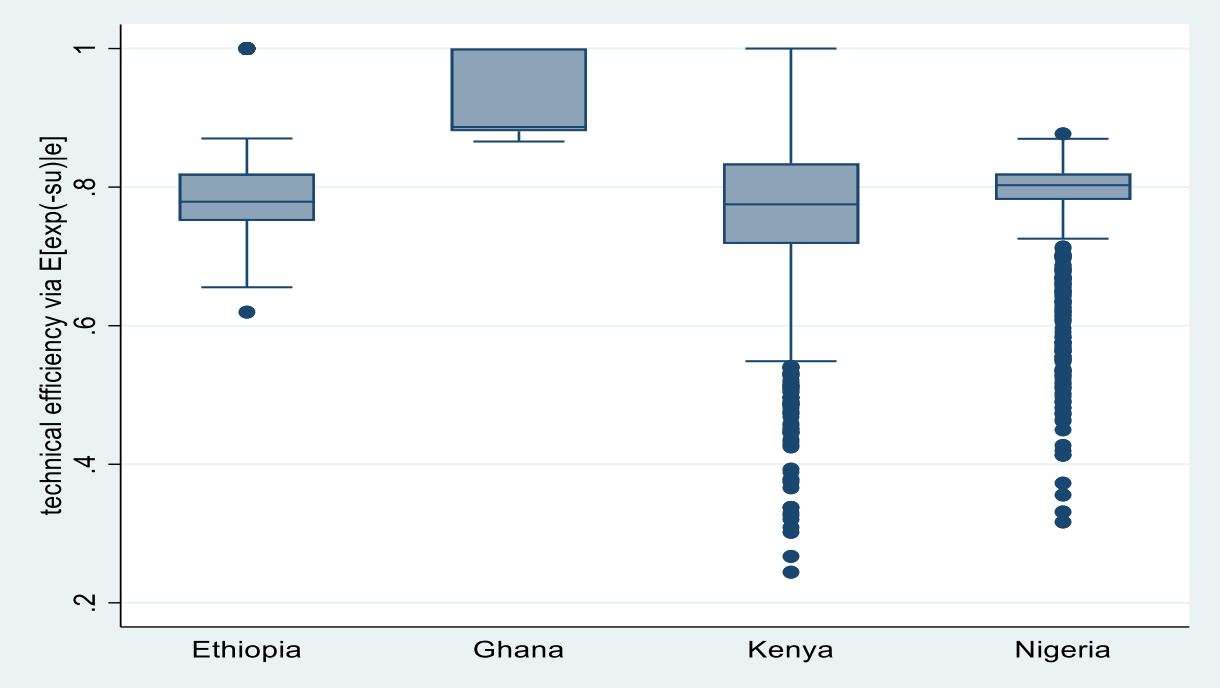


Figure 1: Boxplots of Firm Level Energy Efficiency by Country

The results from the SFA estimation addressing the first objective show that product innovation had a positive and significant effect on energy efficiency.Capital input had a negative effect on energy efficiency, while raw material input had a positive effect on energy efficiency. Top manager experience and firm size had negative effect on energy efficiency, suggesting that weak corporate governance and diseconomies of scale might be at play. Ghana was also found to be more energy efficient than Ethiopia among the four countries.

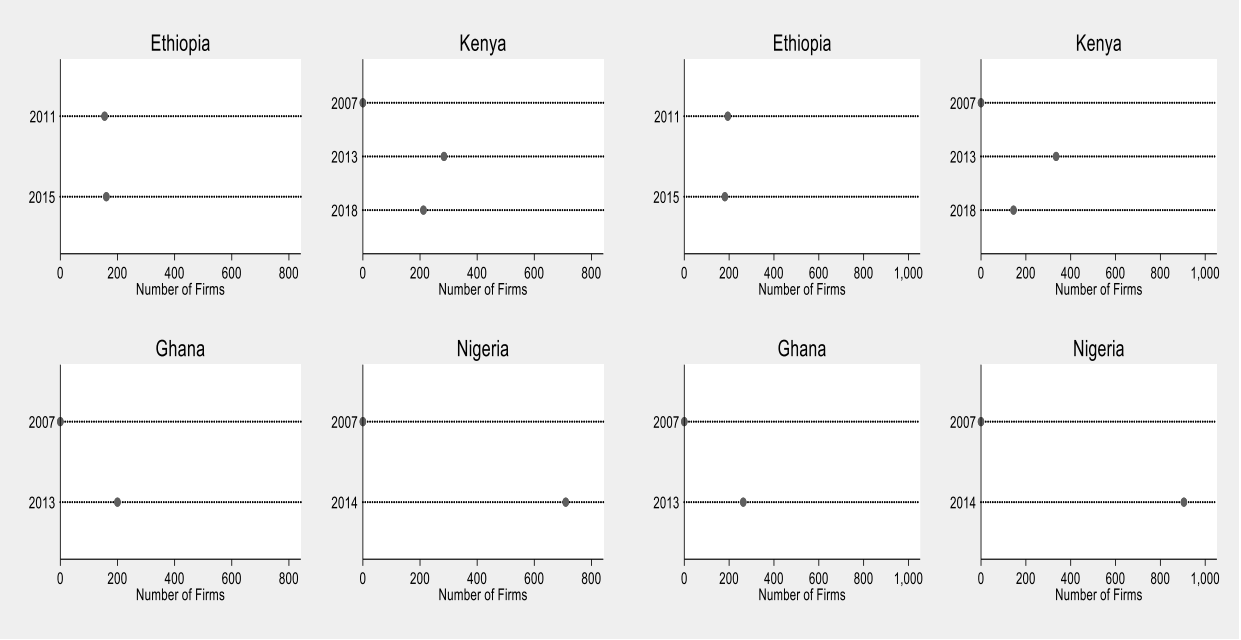
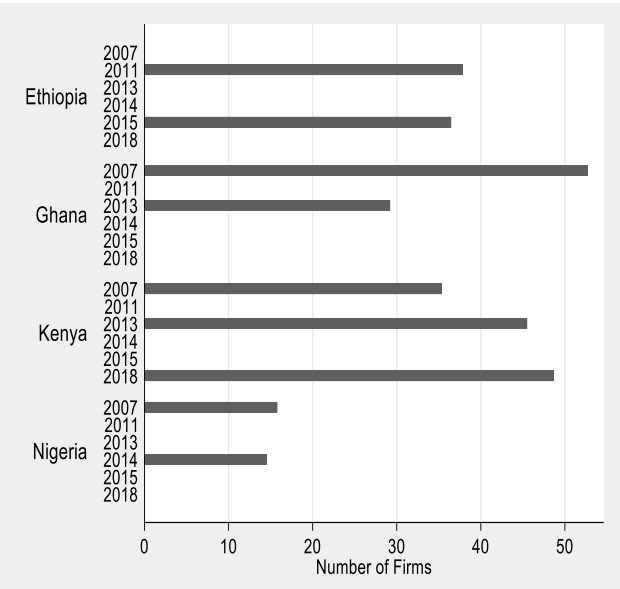


Figure 2: Firms with a New Product Innovation

Figure 3: Firms with New Process Innovation

Results addressing the second objective showed that energy efficiency had a positive and significant effect on TFP, capital productivity, and labour productivity. A one percentage point increase in energy efficiency increased TFP by 9.8%, capital productivity by USD 1.38 and labour productivity by USD 1.22, on average. These results were consistent with previous studies that found a positive relationship between energy efficiency and productivity. We also found a negative effect on firm productivity of having a female top manager alluding to the difficulty of running a manufacturing firm as a female top manager. The results also showed that there was significant variation in productivity across the four countries, with Ethiopia being the least productive and Nigeria being the most productive in terms of both capital and labour.



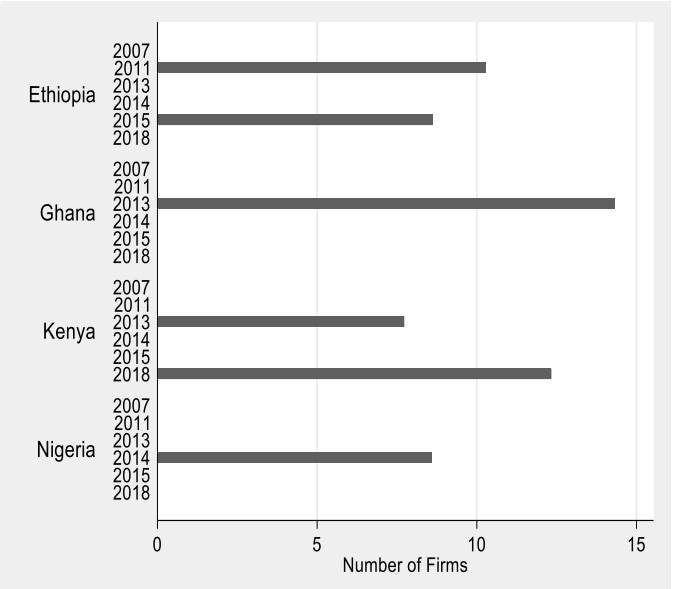


Figure 4: Firms with *F*emale *P*articipation in *O*wnership Figure5: Firms with a Female Top Manager

The results addressing the third objective showed that women's participation in both manufacturing firm ownership and management was very low in all four countries. The results also showed that energy efficiency is an important variable in firm productivity consistently across productivity measures for both men and women-owned enterprises, but the productivity effects are lower for women-owned enterprises.

Policy Implications

Despite the introduction of various policy measures to enhance firm performance in Ethiopia, Ghana, Kenya, and Nigeria, the manufacturing sector has experienced slow growth. The findings of this study offer important policy implications.

Policies supporting surrounding incentives, subsidies, tax breaks, or grants for firms that introduce product or process innovation are likely to foster innovation. This is likely to enhance energy efficiency based on the finding that product innovation has a positive effect on energy efficiency particularly for Ghana. In addition, policies facilitating the diffusion and adoption of new technologies and best practices aligned with innovation can play a key role in enhancing energy efficiency and productivity.

Policies focusing on investments aimed at improving the reliability and quality of the electricity supply, especially in Nigeria, where energy intensity is the lowest among the four countries are likely to improve productivity. This can be achieved by expanding the grid capacity, diversifying the energy sources, upgrading the transmission and distribution infrastructure, and reducing losses and thefts.

Considering that energy efficiency has a positive effect on productivity, policies promoting the use of renewable and clean energy sources, such as solar, wind, or hydro, that can reduce the dependence on fossil fuels can play a role in enhancing energy efficiency and thus productivity.

Lastly, a key policy implication includes addressing the gender gaps and barriers in firm ownership and management, as well as in access to energy and other resources. This could be done by ensuring equal rights and opportunities for women entrepreneurs, providing training and mentoring programs, facilitating access to finance and markets, and creating a conducive business environment for women-led firms. Policymakers should also monitor and evaluate the gender outcomes of their policies and programs and ensure that they are gender-sensitive and inclusive.

The Environment for Development initiative is a capacity-building program in environmental economics focused on international research collaboration, policy advice, and academic training. It consists of centers in Central America, Chile, China, Colombia, Ethiopia, Ghana, India, Kenya, Nigeria, South Africa, Sweden (University of Gothenburg), Tanzania, Vietnam, Uganda, and the US (Resources for the Future). Financial support is provided by the Swedish International Development Cooperation Agency (Sida).