## Extended Abstract
## Please do not add your name or affiliation

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| **Paper/Poster Title** | Climate change adaptation and productive efficiency of subsistence farming: A selection bias-corrected panel data stochastic frontier approach |

**Abstract prepared for presentation at the 96th Annual Conference of the Agricultural Economics Society, K U Leuven, Belgium**

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| **Abstract** | ***200 words max*** |
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| We explore the impact of climate change adaptation on the technical efficiency of Ethiopian farmers by using panel data collected from 6,820 farm plots. We employ Green's (2010) stochastic frontier approach under panel data setting and propensity score matching to address selection bias stemming from observed and unobserved heterogeneities. Our results reveal that practicing climate change adaptation improves production efficiency, in particular, the efficiency of maize, wheat, and barley production. We also show that failure to account for selection bias underestimates the average efficiency level. Our findings imply that the expansion of climate change adaptation at larger scales will provide a double benefit by curbing climate-related risks and by increasing the efficiency of farmers. Moreover, increasing credit access and introducing mechanisms that allow farmers to get enough amount of water during the main growing season will enhance the efficiency of subsistence farmers. All this could assist in transforming Ethiopia's agriculture sector. | |



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| **Keywords** | agriculture; climate change; climate change adaptation; selection bias; technical efficiency |
| **JEL Code** | Q12, Q52, Q54<br>see: www.aeaweb.org/jel/guide/jel.php?class=Q) |


| **Introduction** | ***100 – 250 words*** |
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It is widely recommended that implementing adaptation strategies will help reduce the effect of climate change (Bradshaw et al., 2004; Di Falco et al., 2011; Lin, 2011; Teklewold et al., 2013; Huang and Sim, 2021). Adaptation capacity is determined by the availability of various resources and technologies, which are scarce and not easily accessible by smallholder farmers. At the same time, natural resources available for food production are becoming more constrained. Thus, a sustainable food supply and agricultural sector transformation require an approach that allows producing a higher level of output using the existing level of resources. Increasing production efficiency would be one potential way of achieving this (Wassie, 2014; Lokina and Lwiza, 2018). Hence, the central hypothesis of this study is the following: if farmers can implement climate change adaptation strategies in an appropriate way, it is expected that they will get a double benefit. First, climate adaptation strategies will allow them to abate the effect of climate change by increasing their resilience capacity. Second, climate adaptation strategies will increase farmers' productivity by introducing new or improved agricultural practices. Though this seems theoretically appealing, to the best of our knowledge, no study tried to appropriately measure the effects of implemented climate adaptation strategies on farmers' Technical Efficiency (TE) in the context of Ethiopian agriculture. In response to this,

we explore the effect of climate change adaptation on the TE of farmers operating under subsistence agriculture in the Nile basin of Ethiopia.

| **Methodology** | ***100 – 250 words*** |
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The main challenge to infer causal effects in impact evaluation studies is addressing selection biases arising from observed and unobserved heterogeneities. Failure to address either or both of the two biases will lead to biased and inconsistent TE estimates. For this reason, we measure the impact of climate change adaptation on surveyed farmers' TE following the recent works of Bravo-Ureta et al. (2011) and Villano et al. (2015) who combined PSM to correct for selection bias arising from observable factors with Greene's (2010) proposed SPF model with a correction for unobserved sample selection. Unlike these studies that used the proposed selection bias correction method for cross-sectional data setting, we exploit a similar approach in the panel data setting.

| **Results** | ***100 – 250 words*** |
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The average TE scores reveal that plot adopters are more efficient than plot non-adopters and that this difference is statistically significant after addressing selection bias in both the matched and unmatched samples. For instance, TE, which we estimated using the convectional SPF models, show that, on average, adopters are 4.21 percent and 2.059 percent more efficient than non-adopters in the unmatched and matched samples, respectively. After addressing both types of biases, the TE differential between adopters and non-adopters is 12.37 percent, which is significantly larger than the convectional counterpart (4.21%). This suggests that by implementing climate change adaptation strategies, plots are becoming more efficient. Furthermore, our results reveal that the convectional SPF models underestimate the impact of climate change adaptation on average TE. By estimating the selection bias-corrected SPF models, we show that the impact of adaptation on efficiency is much larger: for the matched sample, the average TE is increased from 45.10 percent to 53.03 percent for adopters and from 44.19 percent to 47.19 percent for non-adopters. We also measure the effects of climate adaptation strategies on each crop's TE. The results reveal that climate adaptation strategies have a crop-specific effect. From the considered crops, climate adopters achieve a higher level of efficiency in maize, wheat, and barley. On the other hand, climate adaptation measures seem to reduce efficiency for teff. This implies that the assumption of climate adaptation strategies being equally effective could be misleading.

| **Discussion and Conclusion** | ***100 – 250 words*** |
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In this study, we investigate the impact of climate change adaptation measures on farmers' TE. For this purpose, we estimate the selectivity bias-corrected stochastic frontier models with the plot-level panel data collected by surveying rural farm households in the Nile basin of Ethiopia. We address selection bias from observed and unobserved heterogeneities by jointly implementing the PSM method with Greene (2010) sample selection model developed for the stochastic frontier framework under panel data setting. Our results show that the presence of selection bias, arising from unobserved factors like motivation, risk attitude, and innate farmers' ability, is affecting farmers' decision of implementing climate change adaptation strategies. Furthermore, we find that climate change adaptation significantly improves TE. That is, farming plots with climate change adaptation are more efficient than farming plots without climate change adaptation. The impact of adaptation becomes larger once we account for selection bias from observed and unobserved covariates, suggesting that failure to address selection bias under non-random assignment of intervention significantly underestimates the level of TE. Furthermore, we show the importance of accounting for weather and soil factors

when estimating farmers' plot-specific productive efficiency, and that the impact of climate adaptation is crop-specific. In the case of our study, climate adaptation in the form of improved varieties and soil conservation activities spur TE of barley, wheat, and maize crops.