Proposal 4: Revealed greenness and response to climate change information: Evidence from cocoa farmers in Country X

PRIMARY IGC THEME: ENERGY & ENVIRONMENT

GRANT TYPE: FULL RESEARCH GRANT

BUDGET: £39,622

PROJECT DURATION: 18 MONTHS

SUMMARY

Climate change and environmental degradation increase the vulnerability of the economy in developing countries. It's of growing interest and importance to policymakers to learn how to achieve the carbon emission reduction targets while upholding productivity. This paper intends to document vulnerable farmers' heterogeneous understanding and beliefs of climate change and how this affects their differential responses to climate-change-resilient practice and other adaptation decisions using evidence from the cocoa industry in Country X. With a lab-in-field design, this project examines cocoa farmers' differential adaptation of shade management and revealed preferences for greenness under two different incentivised subsidy schemes. Comparing farmers' responses to conventional payment for ecosystem services (PES) versus green product price premia (GPP), the results would provide empirical evidence on the comparative cost-effectiveness of PES and GPP subsidy schemes. Information interventions are incorporated to explore the role of information nudges, where farmers are informed of either the direct benefits of shade trees in reducing productivity fluctuation or the indirect benefits in carbon reduction and combating climate change. Lastly, we conduct a set of counterfactual analyses to evaluate the overall treatment effects and related cost-effectiveness of different subsidy schemes given various compositions of green- and non-green-type cocoa farmers.

RESEARCH DESIGN

Model sketch: To examine the impacts of PES and GPP subsidy schemes on farmers' shade management and to quantitatively compare the cost-effectiveness, we develop a theoretical model that rationalizes the heterogeneous farmers' different optimized strategies, and show how the relative effectiveness of the two subsidy schemes depends on the composition of different types of farmers characterized by preferences for climate change risk. In the model, shade trees enter each farmer's production function, with the shadow price reflecting the explicit cultivating cost and farmers' implicit taste. Farmers' preference for climate change consists of (1) the conventional risk aversion, (2) the preference for greenness, and (3) an idiosyncratic preference shock. Farmers with a higher value for greenness or those who are more risk-averse are more likely to adopt a higher level of shade given land conditions and individual observables. We define the effectiveness of a policy as the overall shade level achieved with a given amount of government spending, where shade level can be measured by the number of shade trees per acre or the canopy coverage ratio. The policymaker's objective is to maximize the carbon emission reduction using shade management subject to a budget constraint and a minimum total output. PES incentivizes more tree planting by reducing the shadow price of trees linearly, whereas GPP offers a price incentive for cocoa beans only when the greenness standard (represented by a minimum threshold level of shade trees) is met. We show that traditional PES funded by tax can achieve the equivalent carbon-reduction outcome as the newly proposed GPP. Moreover, the effectiveness of these two subsidy schemes depends on the distribution of the farmers' preferences for climate change.

Lab-in-field design and interventions: To empirically test the model predictions, we use a lab-in-field experiment design to examine the impacts of two subsidy schemes of various hypothetical premium levels. In the onboarding tracking survey, we will track all cocoa farmers who are over 18 years old, have at least 3 years of cocoa growing experience, and make independent production decisions on cocoa farms in 20 randomly selected communities with balanced community level characteristics for each district. We plan to reach 2,000 eligible cocoa farmers in 40 community sites in 2 districts in total. (The current grant we have received from another donor [name of the donor is anonymized by the IGC] can support the field study in one district with a sample of 1,000 farmers and we apply for this grant by IGC to expand our sample size by recruiting 1000 more farmers in another district to cover a more diverse and stratified sample of cocoa farmers.)

In the experiment, eligible cocoa farmers after screening in the baseline are stratified and randomly selected into 100 groups of 20 eligible farmers with balanced characteristics in each district. Eligible farmers are asked to report their production decisions and expected productivity in a hypothetical game, first without any subsidy and then under two different subsidy schemes, i.e., PES and GPP, given homogeneous growing conditions for hypothetical cocoa farms which include soil quality, rainfall, amount of fertilizers applied, etc. Main measures of interest include the number of cocoa trees, the number of shade trees, and expected cocoa bean productivity. We also impose variation in the premium level: GPP premium levels at 5%, 8%, and 10% of the prevailing price, and PES premium levels based on tree survival rate (70%, 75%, and 80%), making it possible to compare the heterogenous treatment effects of different premium levels within subsidy scheme. In addition, to further investigate the role of information frictions or misperceptions, we will conduct two information interventions on randomly selected 66 groups in two information treatment arms, where half (33/100) are informed of the indirect benefits of shade trees in carbon reduction, and half (33/100) of the direct benefits in reducing productivity fluctuation due to climate change. Several attempts are made to ensure close attention by farmers during the experiment: (a) the local agents will help with monitoring, as cocoa farmers usually acquire support from them on cocoa-production-related issues, especially sustainable cocoa planting; (b) we will design some simple questions with objective answers popping up during the game and exploit the variation in the correctness and response time to adjust for participants' inattention bias. Measures will be taken to incentivise truth-telling, such as renumerating by distance to the group mean.

Data collection: In the baseline survey, we collect farmers' demographic information, land information, farming practices including shade management, labour allocation, cost and revenue, and their experience, beliefs, and understanding of climate change. We also ask detailed questions about the property rights of each cocoa farmland since land insecurity and incomplete land property rights are of main concern and are unneglectable in Country X. To evaluate outside options for combating climate change, we include more open-ended questions about non-agricultural adaptations and gold mining. One key section in the baseline survey is to document farmers' heterogeneity in their experiences, beliefs, and expectations of climate change. We collect information on the extent to which farmers agree or disagree with a set of statements about climate change, as well as standard measures for risk preferences. Community-level information is collected from chief farmers and local agents.

We will also recruit agents to conduct field surveys on cocoa farms to obtain accurate information on the GPS coordinates of farm boundaries and shade trees' locations. This data will be essential to evaluating farmers' actual adaptation actions and adjusting for possible misreporting bias based on the comparison of self-reported and predicted shade levels. Additionally, the geographic information makes it possible to link the land with other objective measures of climate change, such as heatwaves and droughts, based on open-source satellite imagery data.

In the lab-in-field experiment, we collect data on each farmer's decisions regarding the number of cocoa trees, the number of shade trees, and expected cocoa bean productivity after each round of hypothetical subsidy schemes and information interventions if applied.

Empirical challenges and identification strategy: We employ a standard two-way fixed effect model to examine the impacts of different subsidy schemes by including a set of different subsidy indicators and the respective interaction terms with information intervention indicators. We also control for the scheme fixed effects, farmer group fixed effects, community site characteristics, and farmer-level characteristics. Standard errors are clustered at the individual level. Coefficients of different subsidy schemes are of key interest, which measure the average treatment effects of given subsidy schemes relative to no-subsidy cases. Coefficients of the interaction terms capture the heterogeneous impacts driven by the respective information frictions. Two sets of outcomes are of interest for our analysis: 1) farmers' adaptation to shade management and other related adaptation behaviours including fertilizer usage, crop allocation, and other investment; (2) farmers' expected cocoa bean productivity per acre. Leveraging the variation of subsidy levels within each subsidy scheme, we further examine the continuous nonlinear relationship between the subsidy level and marginal effects. Combined with detailed information about farmers' knowledge of climate change and revealed preference for greenness, we further explore the heterogeneity in the adaptation by revealed preferences.

There are a few empirical challenges that we need to address. The first challenge is selection bias. Farmers with a higher preference for greenness or more knowledge of climate change are more likely to select into adopting more shade. To relieve this concern: (1) we focus on each farmer's adaptation response under different subsidy schemes, and this panel data structure relieves the concern of individual unobservables and provides a plausible source of variation for identification; (2) the additional information intervention singles out the direct information channel; (3) we control for the prior perception of climate-change-related statements in the baseline. The second is that our estimates could be contaminated by the ongoing real interventions. Cocoa farmers with higher preferences might have already reached a higher shade level, leading to mechanical underestimation of the impact of subsidy. However, we interpret our estimates as the average treated effects given realized shade level. Combining the model and empirical data, we can back out the distribution of the model parameters by capturing farmers' preference for greenness and risk preferences, and then conduct counterfactual analysis by varying the distribution of farmer types. The last is measurement error. Farmers tend to under-report the shade trees on their land, resulting in a biased estimate of the subsidy effect. Using the geo-location of each farmer's land and trees and satellite data, we can predict the tree canopies of shade vs. cocoa trees using machine learning tools. An under-report index can be constructed to adjust for misreporting bias based on the comparison of self-reported and predicted shade levels.

Counterfactual analyses: Guided by the theoretical model, we first calibrate the model and back out the distribution of the key parameters that capture farmers' preference for greenness and risk preferences using the experimental data. Then a set of counterfactual analyses can be conducted to evaluate the overall treatment effects and related cost-effectiveness of different subsidy schemes given various compositions of different types of cocoa farmers.

IGC EVALUATION:

This proposal was ranked highly by the reviewers for its relevance to IGC research strategy, substantial contribution to existing literature, quality of research design, and potential to influence the policy discussion surrounding PES.

PROPOSAL SUMMARY & RESEARCH QUESTION

Proposal summary was well crafted and highlighted a very pressing issue of environment degradation and its impact on agriculture in some countries. Some of the strengths of the summary are as follows:

1. **Setting the context:** The project summary provided important context for the research and highlighted the relevance of this research to policymakers.
2. **Clear research question:** The research question was clearly defined and multifaceted: How do cocoa farmers' understandings and beliefs about climate change influence their adaptation decisions, specifically in the context of shade management? Additionally, it sought to compare the effectiveness of two subsidy schemes, PES and GPP, in promoting climate-resilient practices.
3. **Empirical design:** The research team summarized details of lab-in-field design and the counterfactual analyses without going in a lot of detail to ensure the reviewer of the proposed strategy.

RESEARCH DESIGN

The research design is very clear and detailed with a clear progression of ideas. Some of the strengths of the research design are outlined below:

1. **Theoretical foundation:** The research team outlined a comprehensive sketch of the theoretical model that captured the farmers' heterogeneous preferences for climate change risk and greenness, and how these preferences influenced their adaptation decisions.
2. **Empirical strategy:** The proposal outlined a rigorous research design using a lab-in-field approach with hypothetical subsidy schemes to test the model predictions. The design ensured that the impacts of different subsidy schemes and information nudges were systematically tested. Additionally, the incorporation of real-time monitoring and incentivized truth-telling mechanisms enhanced the reliability of the experimental data.
3. **Data collection:** The proposal outlined a detailed plan for data collection, from baseline surveys to field observations and use of satellite imagery for validation.
4. **Identification strategy:** The identification strategy was clear and well-articulated. The project used a combination of theoretical modelling and lab-in-field experiments to isolate the effects of different subsidy schemes on farmers' shade management practices. The use of a two-way fixed effects model to control for scheme fixed effects, farmer group fixed effects, community site characteristics, and individual farmer characteristics strengthened the causal inference.
5. **Empirical challenges:** The proposal acknowledged potential challenges like selection bias, contamination from ongoing real interventions, and measurement error. The outlined strategies to address these challenges, like the use of panel data and machine learning predictions for tree canopies, were robust.
6. **Counterfactual analyses:** The incorporation of counterfactual analyses grounded in the theoretical model provided a powerful tool to explore the potential impacts of different policy interventions.
7. Overall, the research design demonstrated clarity in its solid theoretical foundation, clear identification strategy, and robust experimental design. The comprehensive data collection plan and detailed exploration of mechanisms ensured a solid foundation for the analysis. The project held promise for producing relevant and actionable insights for policymakers.

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