To my beloved family

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Eyoual Demeke
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Contents

Introduction

Provision of clean energy, building of strong and trustworthy institutions, and a lack of sustainable financial resources to meet the development needs are among the key challenges developing countries are facing. In this thesis, my co-authors and I investigate these issues. From a policy perspective, the topic covered in this thesis falls under the umbrella of five Sustainable Development Goals (SDGs): goal 1 (no poverty), goal 2 (zero hunger), goal 7 (affordable and clean energy), goal 16 (peace, justice, and strong institutions), and goal 17 (partnership for the goals). These are goals that the UN members countries have agreed to achieve by 2030.

To reach the SDGs, developing countries need to mobilize a substantial amount of financial resources. The lack of stable financial resources makes the active engagement of non-government organizations (NGOs) in meeting development goals indispensable. In this regard, charitable organizations play an instrumental role in providing support to vulnerable people. For example, every year, the International Federation of Red Cross and Red Crescent (IFRC) supports 160.7 million people through long-term service and development programs and 110 million people through disaster response and early recovery programs (IFRC, 2015).

Despite the significant support that charitable organizations offer to vulnerable people in developing countries, there is concern regarding the financial sustainability of programs. This is because most of their funding comes from developed countries through donors and NGOs. One way to improve this issue is to tap into local resources such as local donations. Although there is a huge interest in increasing local funding, not enough attention has been given to designing effective fundraising schemes in developing countries. In addition, little attention has been given to the intertemporal donation decisions and the underlying behavior in a developing country context. In **Chapter 1**, we fill this research gap by examining the effect of varying time of payment and commitment on charitable giving in Ethiopia. We assess the donation behavior of subjects in a dynamic setting that involves more than one period.

Even after designing effective fundraising schemes and mobilizing the necessary financial resource, strong and highly trusted institutions are vital to effectively utilize financial resources and meet various development goals. In general, trust has been shown to be a key component in economic activities and is seen by many economists as an important factor for economic growth (Fehr, 2009; Knack and Keefer, 1997) and institutional development (La Porta et al., 1999). Specifically, trust in institutions reduces transaction costs and is an important factor in explaining why trust has a positive impact on economic growth (Fukuyama, 1995). Thus, it is important to understand how economic agents trust institutions per se.

Examining the level of trust firms have in government institutions is vital since such institutions provide services that are important for the survival and growth of firms. If firms have low levels of trust in these institutions, they could be suspicious of policies and technologies that institutions introduce, or they might be reluctant to deliver on their civic and economic responsibilities, e.g. in the area of tax compliance and environmental protection. In a nutshell, if we would like to understand and quantify the role of trust in institutions, we need to have an appropriate measure for it, which we discuss in **Chapter 2**. In this chapter, we consider entrepreneurs in Addis Ababa, Ethiopia, which is currently experiencing rapid economic growth – a process in which entrepreneurs are important actors. Entrepreneurs act as the trustors in their frequent interaction with many different types of institutions, which provides an appropriate setup for investigating trust in institutions.

However, having effective fundraising techniques and highly trusted institutions are not enough as countries also need to identify critical areas to improve among the multitude of problems facing developing countries. The energy sector is among the priority sectors identified in the SDGS, and the last two chapters focus on issues in this sector.

SDG 7 states that access to affordable, reliable, sustainable, and modern energy should be ensured for all. The emphasis given on providing clean energy for all by 2030 stems from the fact that achieving this goal has

significant economic, health, and environmental benefits. For instance, providing access to electricity for households has been found to increase their labor market participation (Dinkelman, 2011). More generally, there is evidence that electrification has large effects on two measures of development: the UN human development Index (HDI) and average housing values (Lipscomb et al., 2013). Reducing reliance on biomass resources will also improve the health situation. Provision of access to clean energy by 2030 is expected to prevent 1.8 million premature deaths per year (IEA, 2017).

The energy sector is a major contributor to climate change, as it accounts for 60 % of the global greenhouse gas emissions (UN, 2016). In particular, deforestation and forest degradation to meet cooking energy needs have been main causes for the loss of irreplaceable biodiversity and destruction of local ecosystems in many developing countries (Köhlin et al., 2011). Thus, in addition to the economic and health benefits, transitioning to clean energy sources will also yield a significant environmental benefit.

In spite of the economic, health, and environmental benefits of using clean energy sources, a large share of the population in developing countries suffer from energy poverty, a term loosely defined as lack of access to clean energy sources and heavy reliance on biomass fuels. Around 14 % of the world's population – 1.1 million people – do not have access to electricity and more than 2.8 billion people lack clean cooking facilities (IEA, 2017). The largest proportions of people who lack access to electricity are found in southern Asia and sub-Saharan Africa. Moreover, the inefficient use of biomass fuels in developing countries has caused 3.8 million people a year to die prematurely from illness attributable to household air pollution (UN, 2016). In **Chapter 3**, using panel data from Ethiopia, we analyze the persistence of energy poverty.

Besides providing access to affordable energy sources, ensuring their reliability is another important issue. Previous studies have provided ample evidence regarding the indispensable importance of access to a reliable supply of electricity for economic growth (Andersen and Dal-

gaard, 2013). However, a sufficient and reliable supply of electricity is far from a reality in developing countries, and this is a problem especially in sub-Saharan Africa. In sub-Saharan African countries, the electricity supply is characterized by frequent and lengthy outages (Andersen and Dalgaard, 2013). Frequent unannounced outages that last for many hours are currently reducing the benefit of access to electricity to both households and firms in developing countries.

Lack of reliable electricity service has been listed as a major obstacle to the growth of firms in developing countries. In the 2017 World Bank Enterprise Survey (WBES), about 40% of firms in sub-Saharan Africa stated that the shortage of electricity was a major constraint to their operations (WBES, 2017). The same survey also found that the average firm in sub-Saharan Africa lost about 49 hours of economic activity in a typical month as a result of outages in 2015. Among Ethiopian firms, an average firm lost about 47 hours of economic activity per month as result of outages in the same year.

Firms have employed a variety of strategies to mitigate the negative impacts of power outages in developing countries. Examples include making the production more flexible and owning backup generators. But backup diesel generators are costly and it has been estimated that in sub-Saharan Africa, self-generated electricity costs three to ten times as much as the electricity purchased from the grid (Eifert et al., 2008; Foster and Steinbuks, 2009). Long-term and sustainable solutions to improve the reliability of the electricity supply in a country include investments in generation and distribution capacity together with a more flexible price-setting scheme, such as peak-load pricing. Thus, it is necessary to understand customers' willingness to pay for such improvements. In **Chapter 4**, we investigate the willingness of micro-, small-, and medium-sized manufacturing enterprises to pay for improvements in the reliability of electricity supply.

Summary of chapters

Chapter one: Time Preference and Charitable Giving: Evidence from Ethiopia

We conduct a three-round experiment to investigate the effect of varying time of payment and commitment on charitable giving. Using a between-subject design, we randomly assigned individuals into one of three groups, i.e., donate today, commit today and donate later, and pledge today and make final donations later. Our findings show that asking donors to make a binding commitment to donate later increases donations by 37% compared asking them to donate immediately, which currently is the predominant fundraising strategy for most charity organizations. The treatment effect in our study is almost twice the effect size found in previous studies such as Breman (2011). We also find that the difference in donations between the three groups is not correlated with time-inconsistent behavior of individuals.

Our findings suggest that instead of asking for donations immediately, charity organizations in developing countries can increase donations by asking individuals for a binding commitment to make future donations. Another implication of our results is that the strategy of offering potential donors a chance to make a binding commitment to make future donations can be applied across the board regardless of their time preference.

Chapter two: *Measuring Trust in Institutions*(co-authored with Fredrik Carlsson, Peter Martinsson and Tewodros Tesemma)

Unlike previous studies, we measured trust in institutions by using a novel institutional trust experiment with employees at government institutions as trustees and stated trust questions towards institutions in general and employees at institutions. We find rather strong evidence that stated trust both in specific institutions and in the employees therein is positively correlated with the amount sent in a trust game to the employees of the same institution, and the correlation is statistically significant. We find that generalized trust is only weakly correlated with

trust in specific institutions, when elicited both by using a trust game and by using survey questions. However, the correlation between trust in a specific institution elicited through a trust game and stated trust in the same institution is stronger and statistically significant. Thus, our findings suggest that generalized trust is not an appropriate measure of institutional trust and that more specific institutional trust measures should be used. Moreover, we find that entrepreneurs have a low level of trust in institutions and that it differs depending on the institution with trust in our sample being lowest for the electric utility and the tax authority. This finding indicates that it is important to measure institution-specific trust.

Chapter three: *The Persistence of Energy Poverty: A Dynamic Probit Analysis*(co-authored with Yonas Alem)

Using a three-round panel dataset, i.e., the Ethiopian Urban Socio-economic Survey (EUSS), we estimate a model of the probability of being energy poor and investigate the persistence of energy poverty in urban Ethiopia. We also study the impact of energy price inflation, which Ethiopia experienced 2007–2009, on energy use and energy poverty. We find that a household that is energy poor in one round is up to 16% more likely to be energy poor also in the subsequent round. This provides evidence of an energy poverty trap, from which it is difficult to exit without external interventions. Employing dynamic Probit models, we find that an increase in the price of kerosene – the most important fuel for the urban poor – is associated with an increase in the use of charcoal.

Our findings have two important policy implications. First, policy measures such as provision of microfinance opportunities will enable households to overcome the capacity constraints currently preventing them from acquiring a modern and relatively costly cooking appliance and thus to switch to clean energy sources. Second, policy makers should design policies that can protect the welfare during times of energy price inflation to protect households from backsliding to biomass resources.

Chapter four: *Cost of Power Outages for Manufacturing Firms in Ethiopia: A Stated Preference Study* , (co-authored with Fredrik Carlsson, Peter Martinsson, and Tewodros Tesemma)

In this paper, we measure the willingness to pay for improved reliability of electricity supply among micro-, small-, and medium-sized manufacturing enterprises in the capital of Ethiopia, Addis Ababa. Since we focus on the value of improvements that bring reliability to levels that do not exist today, we employ a stated preference method. We focus on two broad aspects of power outages: the number of outages experienced in a month and the average length of a typical outage.

Our results show that the willingness to pay, and thus the cost of power outages, is substantial. The estimated willingness to pay for a one power outage per month corresponds to a tariff increase of 16 %. The willingness to pay for reducing the average length of a power outage by one hour corresponds to a 33 % increase. The compensating variation for a zero-outage situation corresponds to about three times the current electricity cost. There is, however, considerable heterogeneity in costs across sectors, firm sizes, and levels of electricity consumption. Policy makers should consider this observed heterogeneity when it comes to aspects such as where to invest to improve reliability and different types of electricity contracts.

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Time Preference and Charitable Giving: Evidence from Ethiopia*

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Abstract

We conduct an experiment to investigate the effect of varying time of payment and commitment on charitable giving. Using a between-subject design, we randomly assigned 437 participants to three groups: donate today, commit immediately and donate later, and pledge immediately but donate later. Asking donors to commit to donate later increases donations by 37% compared to asking donors to donate immediately. The effect found in our study is almost twice larger than the effect size found in previous studies. When donors are asked to make a non-biding pledge immediately and donate later, donations are not statistically significantly different from asking donors to donate immediately. The difference in donations between the three groups is not correlated with time inconsistent behavior of individuals. Our findings suggest that instead of asking for donations immediately, charity organizations in developing countries can increase donations by providing individuals with a binding commitment to future donations.

JEL Codes: C91,D64, D91,L31

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1 Introduction

Charitable organizations play an instrumental role in providing support to vulnerable people in the world. For example, the International Federation of Red Cross and Red Crescent (IFRC) supports 160.7 million people annually through long-term service and development programs and 110 million people through disaster response and early recovery programs (IFRC, 2015). Most of the charitable giving comes from the developed countries through donors and non-governmental organizations.[1] Recently, however, the amount of external funds allocated for charitable organizations have fluctuated, raising concerns about the financial sustainability of most programs.[2] One way to combat this sustainability issue is to tap into local resources such as local donations. Despite the huge interest in increasing local funding, not enough attention has been given to designing effective fund-raising schemes in developing countries.

Previous studies on donation conducted in both developed[3] and developing countries indicate that differences exist in terms of both amounts contributed and the effectiveness of fund-raising mechanisms. Henrich et al. (2001) find that the average contribution is higher in developing countries than in developed countries. Other studies have looked at factors affecting donation decisions in developing countries. For example, using an economic experiment, Lambarraa and Riener (2015) find that anonymizing donations instead of making them public increases contributions. Batista et al. (2015) find that donations are higher when an option to donate in-kind is provided. Overall, the studies from developing countries point to the importance of designing better fund-raising schemes that fit the culture and norms of the developing world.

[1] For instance, the budget for the International Committee of the Red Cross was over 1 billion Swiss francs (over USD 862 million) for 2018-2019, and most of the budget comes from the United States, the European Union and international organizations (IFRC, 2017).

[2] The net Official Development Assistance (ODA), from Development Assistance Committee (DAC) members increased in absolute value, but declined from 0.31% of gross national income to 0.6% in real terms from 2016 (OECD, 2018)

[3] For a summary of studies in developed countries see Jasper and Samek (2014),Vesterlund (2016), and Andreoni and Payne (2013)

The effectiveness of a fund-raising scheme also depends on how well it considers donor behavior. Factors that have been found to be important in previous studies include the option of making contributions either in cash or by using a debit card (Soetevent, 2011), whether there is a relationship with the solicitor or not (Castillo et al., 2014), the way messages are framed (Alem et al., 2018), and whether the donation messages provide social information (Croson and Shang, 2008; Shang and Croson, 2009).

In this paper, we conduct an experiment where we vary the timing of payment and commitment on donation behavior in a developing country context. We also investigate the mechanisms behind the difference in donations when the timing of payments and donation commitments is changed. Previous studies in developed countries have documented that individuals tend to donate more when asked to donate later than when asked to donate immediately. This behavior is called *time-inconsistent giving* (Andreoni and Serra-Garcia, 2016), and may partly be due to variation in time preference of individuals, specifically present bias or having a particular weight on immediate consumption (Andreoni and Payne, 2013; Breman, 2011). Therefore, we empirically explore the less-investigated behavioural links, specifically time preference of individuals, and how it influences individuals donation decisions when the timing of the payment and donation commitment is varied.

We designed a donation experiment in collaboration with a local charity organization known as Mekedonians Humanitarian Association (MHA) and based in Addis Ababa, Ethiopia. Potential donors were randomly assigned to control and treatment groups. In the control group, *donate today*, participants were asked whether they would like to donate immediately. In the two treatment groups (T1 and T2), we varied the timing of the payment and the donation commitment. In T1, *commit today and donate later*, participants made a binding commitment to donate in the future (in two weeks). In T2, *revise pledge and donate later*, we investigated the effect of providing the opportunity to change the promised donations. In this group, potential donors made non-binding pledges to donate in a future round of the experiment. The participants were informed that

they could change the amount pledged in the future. By analyzing the difference in donations between the treatment groups, we are able to gauge the effectiveness of the fundraising strategy of varying the timing of commitment and payment in a developing country context.

In addition, we explore how people's time preferences influence their donation decisions with varying the timing of payment and donation commitment. We measured time preference in an incentive-compatible manner using the multiple price list (MPL) approach[4], where subjects choose between receving money now or receving a higher amount in later time periods. In addition, we analyze how the heterogeneity in payment periods (donation treatments) correlates with experimentally elicited time preference of individuals.

The effect of commitments has been studied in a variety of contexts including savings behavior (e.g., Ashraf et al., 2006; Thaler and Benartzi, 2004), fertilizer use by farmers (Duflo et al., 2011), and managment of addictions (e.g., Bernheim and Rangel, 2004; Giné et al., 2010), but little evidence exists in the donation literature.[5] Using a dictator game in a laboratory experiment in Spain, Kovarik (2009) shows that extending the time of payment symmetrically to both dictators and receivers has a negative effect on donations. The asymmetrical effect of changing the time of payment and providing commitment have been investigated by Breman (2011) and Andreoni and Serra-Garcia (2016). These are the two studies that are most closely related to our paper. Andreoni and Serra-Garcia (2016) used a laboratory experiment with students from USA to examine the effect of extending actual transfer on doantion probabilty. The study documents the existence of time inconsistencies in charitable giving and identifies social pressure as the main driver of the time-inconsistent behavior. However, the authors did not explicitly investigate the relationship between people's donation decisions and time preferences, which is one of the focus areas in the present study. Our approach also differs from Andreoni and Serra-Garcia (2016) in that

[4]Dean and Sautmann (2016) find experimental measures of time preference obtained using MPL vary with savings and financial shocks.

[5]See Bryan et al. (2010) for an overview of evidence on commitment devices

students can donate from the total earnings they receive after completing a task rather than from a show-up fee that can be considered windfall income.[6]

Using two field experiments with registered donors in Sweden, Breman (2011) found that average contributions increased when people were asked to contribute more in the future, and the result persisted even after 12 months. Our study differs from Breman (2011) in three important aspects. First, we explicitly examine how people's time preferences influence their contribution when payments are delayed. Second, we look into internal resource mobilization in a developing country context, which differs from that of developed countries. Third, instead of just registered donors, our sample also includes individuals who have never donated to a charity organization before. Registered donors are probably a selected group with specific characteristics such as high levels of altruism, which makes the effects from providing commitment and delaying the time of payment difficult to generalize to the whole population. Thus, we are able to investigate the effect of providing commitment and delaying the timing of payment (the treatment) on whether people decide to donate as well as how it relates to time preference of people.

Our study presents three key findings. First, by providing an opportunity to commit to future donations, it was possible to increase the amount donated by 37 %. Second, allowing donors to make a revisable pledge also increases donations compared with when asking for donations to be made immediately, but the effect was not statistically significant. Third, experimentally measured time preferences of individuals and classifications based on hyperbolic discounting (present-biased and future-biased) do not explain the donation decisions of subjects when varying the timing of commitments and payments.

The remaining part of the paper proceeds as follows. Section 2 presents the experimental design and hypotheses, Section 3 provides both descriptive

[6] By conducting a dictator game, Carlsson et al. (2013) show that the amount donated by subjects is higher when the earning is a windfall gain.

and econometric analyses of the results, and Section 4 presents the conclusion.

2 Experimental Design and Hypotheses

We conducted a three round experiment with undergraduate students in the regular program of College of Business and Economics at Addis Ababa University. Each participant received a show-up fee of 50 birr and 100 additional birr[7] for completing the questionnaire in all rounds. In the first round, we used the multiple price list (MPL) approach to experimentally measure the participants' time preferences. After one week, we carried out a donation experiment. In the last round, all participants were asked survey questions regarding their risk attitudes, family background, and previous interaction with the charity organization.

2.1 Donation Experiment

We carried out an effort task where participants earned 100 birr (USD 3.66), which corresponds to about half a day's salary for fresh business graduates in the Ethiopian bank sector, by completing a questionnaire on career aspirations and perceptions of corruption.[8] The rationale behind the questionnaire was to create a sense of earning among the participants and to reduce the possibility of them treating the earnings as windfall money (Carlsson et al., 2013; Clingingsmith, 2015). After completing the questionnaire, participants were given a brief introduction to/description of a local charity organization named the Mekedonians Humanitarian

[7]USD 1=27.3 birr at the time of the experiment in May 2018.

[8]Since we follow a between subject analysis, we do not except the survey questions,which are the same in all groups, to influence the treatment effect. Nor do we believe that the responses to the aspiration and general corruption perception questions will influence the participants' donation behavior. The charity organization we selected is widely known for its transparency, and it is thought to be less susceptible to corruption than other organizations. We also tried to eliminate the risk of the research team misusing the money by requesting a written report from the organization stating that they were aware of the study and assuring that the money donated in the experiment would be used solely for the charity organization.

Association, commonly referred to as Mekedonia.[9] The charity organization was chosen because it is not affiliated with any political or religious organization. The texts used to introduce the charity organization were taken directly from its website. After introducing the charity organization, we presented a donation question that varied depending on the group an individual was randomly assigned to. However, in all groups, the show-up fee was not part of the donation, and participants were allowed to donate any amount between 0 and 100 birr. In what follows, we explain the control and the treatment groups.

Control group: Donate today

After introducing the charity organization, participants in the control group were asked whether they would like to donate to the organization "today." If they chose to donate a positive amount, the money would be deducted from their total earning in the second round and given to the charity organization. This group is used as a benchmark group because it resembles both the current fund-raising strategy of the charity organization under consideration and the fundraising schemes of many other charity organizations in the world.

Treatment 1: Commit today + Donate later

Participants were first given the same introduction to the charity organization as the control group. Then they were asked if they would like to donate to the organization from their third round earnings, which were going to be paid. Participants were informed that their donation decision in the second round was final, as they would not be able to change it in the third round. In other words, the donation amount stated in the second round can be considered a binding commitment to donate from their third-round earnings.

[9] "Mekedonians Humanitarian Association is an Ethiopian resident charity established to support elderly people and people with disabilities who otherwise have no means of survival by providing them with shelter, clothing, food, and other basic services."

Treatment 2: Pledge today + Donate later

Following the presentation of the charity organization, the participants in this treatment group were given the opportunity to pledge the amount they wanted to donate from their third-round earnings. However, they were also informed that they could change the amount pledged in the third round. In the third round, participants were reminded about the amount they had pledged in the second round and then given a chance to confirm or revise the amount they were about to donate to the charity organization. Therefore, the amount stated in round two was a mere non-binding pledge, while the final donation decisions were made in the third round.

The reason for introducing T2 is that previous studies have identified inconsistencies between expected preference in the future and actual behavior (see, e,g., Heidhues and Kőszegi, 2017; O'Donoghue and Rabin, 1999; Schelling, 1978). Inconsistencies are also manifested in the area of donations as shown by Rogers and Bazerman (2008), which could mean lower donations in the long run. Therefore, besides knowing the effect of varying the timing of payments on donations, it is crucial to provide an opportunity to revise past decisions and investigate the proportion of people that will stick with their pledges.

2.2 Time Preferences

We used an incentivized choice experiment to elicit people's time preferences. The multiple price list (MPL) is an incentive-compatible measure of time preferences, where subjects make a choice between receiving money now or later. Individual discount factors are calculated by identifying the point at which an individual becomes indifferent between the two options given. But MPL has the caveat of relying on restrictive assumptions such as linear utility functions, which imply a higher discount rate and a discontinuous budget (Andersen et al., 2008). One way to get around the problem of discontinuity in the budget lines is to use the convex time budget (CTB) (Andreoni and Sprenger, 2012). However, in terms

of field applicability, MPL is easier to comprehend than CTB, making it the preferred method in our setting. MPL has been used successfully in both developing and developed countries (e.g., Harrison et al., 2002; Meier and Sprenger, 2010; Tanaka et al., 2010).

We measure time preferences by looking at the choices subjects make between two sure payoffs at different points in time. We asked the subjects to choose between a smaller reward in the earlier time period (t_1) and a larger amount in the later time period (t_2). We presented them with a choice list where the amount in period t_2 was fixed and the period t_1 payoff increased monotonically. An example of the choice list presented to the subjects is shown Appendix A.1. As can be seen from the example choice list, the participants were asked to make two sets of decisions (eight decisions in each choice set), where in first choice set they had to decide between a smaller amount today (t_1) and a larger amount in two weeks (t_2) and in choice set 2 they had to decide between a smaller amount in two weeks (t_1) and a larger amount in four weeks (t_2). The order of the different payments at t_1 was not randomized. Instead it was monotonically increasing. However, we did randomize the order in which the choice sets were presented to the subjects, which enables us to see the influence of staring with choice set 1 or choice set 2 in the time preference experiment.

The information obtained from the two choice sets enables us to measure individual discount factors, and comparing the discount factors between the two choice set enables us to examine the presence of hyperbolic discounting. Respondents who had a lower discount factor in choice set 1 than in choice set 2 are classified as being present-biased. In contrast, the discount factor of future-biased subjects is higher in choice set 1 than in choice set 2. Time-consistent subjects have the same discount factor in both choice sets.

The experimental measures of time preferences may not fully capture people's true inter temporal preference for several reasons. For example, the participants' decision may be biased toward choosing the instant offer if they believe that the experimenter might otherwise not end up

paying them the promised payments. To avoid uncertainty related to trust in the experimenter, all participants were informed that they would receive a confirmation letter signed by the principal investigator and the department of economics and guaranteeing the payments from the experiment. The confirmation letter also contained information about the amount that would be paid to participants, the date of payment, where they could withdraw the money, and a phone number they could call if they had any questions.

Transaction costs and the time horizons involved can also bias time preference measures (Cohen et al., 2016). To make earnings truly immediate and reduce transaction costs, we used mobile payments enabling participants to get cash quickly using the bank's agent on the university campus. The office of the bank agent is located between the main gate of the College of Business and Economics and the building where most of the classrooms are located. The use of mobile payments enabled us to collect administrative bank data on three aspects: i) whether subjects withdrew the payment in cash or used it to buy cell phone airtime, ii) the amount withdrawn from the account in the first transaction made or the amount of airtime bought, and iii) the number of days the money remained in the account.

2.3 Experimental Procedure

The experiment was conducted in spring 2018 at the College of Business and Economics in Addis Ababa University and consisted of three rounds, each of which contained nine sessions. All sessions were completed with paper and pen and with separate instructions and decision sheets. Participants were students recruited from the College of Business and Economics, Addis Ababa University, which has four departments: Economics, Management, Public Administration, and Accounting and Finance. We contacted each department and posted an advertisement on the bulletin boards of each dean's office. The boards were selected as they are mainly used to communicate important information such as starting dates of classes, exam schedules, and changes in class schedules. Thus, students regularly

check the bulletin boards for information. In order to reach out to students who might not have seen our advertisements at the dean's offices, we also posted them outside the student cafeteria and by main entrance to the college. The advertisements stated that a three-round experimental study would be carried out with second- and third-year students at the College of Business and Economics, and that monetary compensation would be provided for the time spent.[10]

On average around 49 students participated in each session, yielding 437 participants in total. The participants were not informed about the content of the experiment a priori. At the beginning of each session, instructions about the experiment were distributed to each individual and read out loud by the experimenter. Questions regarding the experiment were answered privately and only examples from the instructions were provided to answer any questions. The participants were also informed that payments would be made privately in a separate room next to the experiment hall.

Figure 1 summarizes the experiment in each period and the time at which the corresponding payments were made. In the first round, we conducted the time preference experiment and subjects answered some basic demographic questions about themselves. After one week, we conducted the second round by implementing the donation treatment. The respondents were first asked to complete a questionnaire on perceptions of corruption and career aspirations. They were told they would earn a 100 birr for doing so. After ensuring that the students had provided their IDs and that they had answered most of the questions, each student was given a confirmation letter. In this letter, we stated the amount they would receive at the end of the experiment, i.e., a show-up fee of 50 birr and an additional 100 birr for completing the questionnaire. In the third round, all participants were asked detailed control questions, for example about personal interaction with the charity organizations, except those in T2, who, in addition to the control questions, also made donation decisions.

[10]Students were told that only those who were willing to participate in all three rounds were eligible for registration.

After the first round, participants were assigned to a specific session and then remained in that session in the last two rounds.

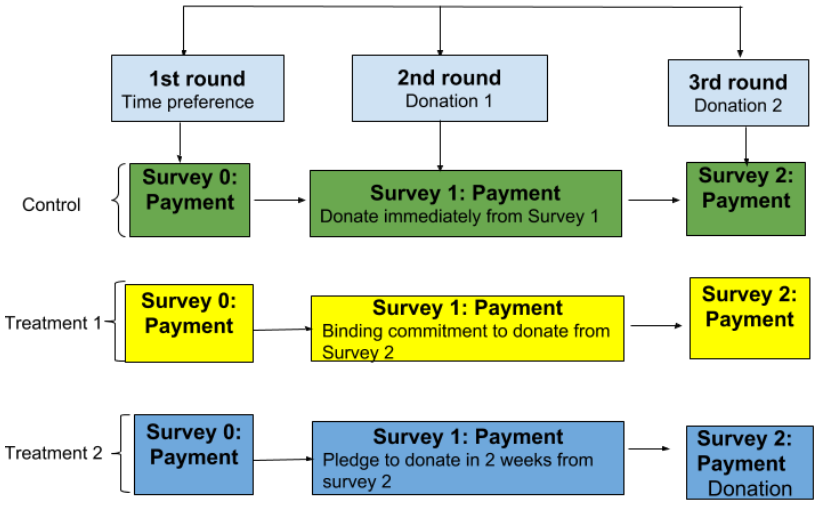

Figure 1: Experiment and payments

The experiment was conducted in Amharic. An English version of the instructions is presented in Appendix A.1. All rounds involved an effort task where subjects were paid 100 birr (USD 3.66) for completing the questionnaire and a show-up fee of 50 birr (USD 1.83). In the first round, the questionnaire involved basic demographic questions, while in the second round it contained questions on career aspirations and perceptions of corruption. In the third round, the questionnaire consisted of detailed individual and household-related questions and questions on previous interaction with the charity organization (Mekedonians Humanitarian Association).

On average, each session in the three rounds lasted around 60 minutes and each respondent earned 220 birr (USD 8.06), 150 birr (USD 5.49), and 150 birr (USD 5.49) for the first, second, and third rounds, respectively. Thus, the average total earnings from the three rounds for each participant was approximately 520 birr (USD 19.05). The participants were informed that the total earnings from each experiment would be paid in private.

All earnings except those from the time preference experimentt,[11] were put in an envelope and handed over to the participants in a different room, in line with the instructions provided before the participants made their decision.

2.4 Hypotheses

In this section, we first present a dynamic version of a standard charitable giving model. Then we put forward some hypotheses on how our treatments influence the subjects' donation behavior. Our hypotheses are based on variants of the frameworks presented by Breman (2011) and Andreoni and Serra-Garcia (2016).

Charitable giving could be driven by altruistic motives of wanting to do good as well as warm glow from own donations. Following the seminal paper by Andreoni (1990), we use the warm glow model to understand individual donation decisions.[12] *Warm glow* implies that individuals get additional satisfaction from doing something good, which is modeled by directly including the donation in the utility function. Let us assume that an individual has an endowment of E in each period, and that she can decide to donate an amount d. The utility function can be expressed as

$$u = u(x_i, D, d_i)$$

where x_i represents the composite private good, d_i is individuals donation to the charity and $D = \sum_{i=1}^{n} d_i$ is the total donation by all individuals.

[11] Using a lottery, we randomly selected one of the 16 decisions and this choice determined when they would receive their time preference earnings. Twenty-five percent of the participants received their earnings at the end of the first round and 51% received it after two weeks, which means that 76 % of the participants received their earnings from the time preference experiment before the third round. Only 24% received their time preference earnings after the third round and after four weeks of the first experiment.

[12] Hochman and Rodgers (1969) provide an alternative model where individual donation decision is modelled as a contribution to a public good. They show that charitable giving motivated by altruism creates a public good out giving.

In our experiment, the participants were asked to donate to a charity organization that provides shelter and food to elderly and disabled individuals. Thus, the utility a person experiences from the provision of the public good (D) is expected to be realized in the future, and it does not vary across treatment groups. In what follows, we will drop "D" from the utility function, as it does not vary across the treatment groups, and we will also drop individual subscripts.

Using a β-δ model (Laibson, 1997) for two time periods, we present the utility functions for each treatment group. Subscripts 1 and 2 represent the current (period 1) and later period (period 2). We assume a utility function that is linear in the consumption of a composite private good. For donation, there are two elements: i) a part that is linear in donations and ii) deviation from some reference level of donations with which individuals compare their donations, and this part enters the utility function in a non-linear way. The reference donation level could be the amount that individuals think is socially acceptable based on the social norm in the community.

As we use the β-δ model, β represents the weight individuals put on consumption today compared with future consumption and δ denotes the discount factor, which is assumed to be less than one. Individuals with $\beta < 1$ are present-biased and show a particular desire for immediate consumption, while $\beta > 1$ indicates a future-biased individual. We also assume the two goods are additively separable. γ represents the weight attached to the benefit obtained from donations and α stands for the weight assigned to the difference between one's donation and the reference donation level ($\overline{d}$). The earnings from the experiment are denoted E, which is kept constant in all groups and across periods. The optimal donation level is obtained from the following individual utility maximization problem:

$$\max_{x^1, d^1, x^2, d^2} \quad x^1 + \beta\delta x^2 + \gamma(d^1 + \beta\delta d^2) - \alpha[(d^1 - \overline{d})^2 + \beta\delta(d^2 - \overline{d})^2]$$

$$\text{subject to} \quad \sum_{t=1}^{2}(x^t + d^t) = \sum_{t=1}^{2} E^t$$

In this study, we employ a simple two-period donation analysis and explore fundraising schemes involving intertemporal donation decisions where the timing of donation commitments and payments is varied in different groups. The benchmark group represents a donation scheme where potential donors are asked to donate immediately. We call this group *donate today* . In this case, the donation decision is made at time t. An alternative fund-raising strategy is to ask for donations in the future, and an individual decides whether she would like to donate at time $t + k$. In this paper, we vary the time at which donation decisions are made. In T1 (*commit today and donate later*), the final decision to donate in the future (period 2) is made today (period 1). On the other hand, in T2 (*pledge today and donate later*r) the actual decision to donate in period 2 is made in period 2.

In the experiment, we expect individuals to experience warm glow at different points in time as we varied the time between making a donation commitment and paying the donations in different groups. Andreoni and Payne (2003) and Breman (2011) assume that individuals experience warm glow either at the time of giving or at the time of making a binding commitment, which is even before the actual donations are transferred. We assume that this holds, so in the *donate today* and *commit today and donate later*, warm glow benefits are experienced in period 1 as individuals make commitments or donations in the same period. But those in T2, get to enjoy warm glow both from making the revisable pledge in period 1 and from the actual donations in period 2. The benefit from giving donations comes at the expense of forgone private consumption. The period in which the cost of donation is incurred is varied across the groups. In the *donate today* group, the cost of donating is felt immediately (in period 1), while in the other treatment groups, where donations are made in the future, the cost of donating is incurred in period 2.

Given the features of the different treatments in the experiment, we will now show what the utility maximization problem and the general β-δ model presented above look like in each treatment group. The time period is shown as a superscript of x and d, while subscripts represent the treatment groups. In the control group, both the donation decision and the donation payments are made in period 1. Individuals in this group only donate in period 1, indicating that d_c^2 is equal to zero and the decision parameters are x_c^1 and d_c^1. Thus, the corresponding individual utility maximization problem is:

$$\max_{x_c^1, d_c^1} \quad x_c^1 + \beta\delta x_c^2 + \gamma(d_c^1) - \alpha[(d_c^1 - \overline{d})^2]$$

$$\text{subject to} \quad x_c^1 + d_c^1 = E^1$$
$$x_c^2 = E^2$$

The first order conditions are:

$$1 = \quad \lambda_1 \tag{1}$$

$$\gamma - 2\alpha(d_1 - \overline{d}) = \quad \lambda_1 \tag{2}$$

$$x_c^1 + d_c^1 = \quad E$$

λ_1 indicates the marginal utility of income or the endowment (E). Given the above first-order conditions, for individuals in the control group the optimal levels of donations (d_c^{1*}) and consumption of composite private good x_c^{1*} are:

$$d_c^{*1} = \frac{\gamma - 1}{2\alpha} + \overline{d}, \qquad x_c^{*1} = (E - \overline{d}) - \frac{\gamma - 1}{2\alpha} \tag{3}$$

Subjects in treatment one, get the opportunity to make a binding commitment to make a future donation. As a result of making a binding commitment in period 1, they experience the warm glow of future donations instantaneously at that time. For individuals in treatment one, d_{T1}^1 is equal to zero and

the decision parameters are x^2_{T1} and d^2_{T1}. The maximization problem for those in treatment one is given as follows.

$$\begin{aligned} \max_{x^2_{T1}, d^2_{T1}} \quad & x^1_{T1} + \beta\delta x^2_{T1} + \gamma d^2_{T1} - \alpha[(d^2_{T1} - \overline{d})^2] \\ \text{subject to} \quad & x^1_{T1} = E^1 \\ & x^2_{T1} + d^2_{T1} = E^2 \end{aligned}$$

The first order conditions are:

$$\beta\delta = \quad \lambda_2 \tag{4}$$

$$\gamma - 2\alpha(d^2_{T1} - \overline{d}) = \quad \lambda_2 \tag{5}$$

$$x^2_{T1} + d^2_{T1} = \quad E$$

Therefore, the optimal levels of d^{2*}_{T1} and x^{2*}_{T1} for individuals in treatment two are given below:

$$d^{*2}_{T1} = \frac{\gamma - \beta\delta}{2\alpha} + \overline{d}, \quad x^{*2}_{T1} = (E - \overline{d}) - \frac{\gamma - \beta\delta}{2\alpha}, \tag{6}$$

Comparing the first-order conditions with respect to x and d for the control group and treatment one gives important insights. First, comparing equations 2 and 5, we see that the expression for the marginal utility of donations is 1, which indicates that individuals in both the control and treatment one experience the warm glow benefit of donating in period 1. In contrast, comparing equations 2 and 5, we observe that the marginal utility from private consumption (x^1_c) is 1 for those in the control group while it is $\beta\delta$ for treatment one. In other words, an individual in the control group donates by forgoing private consumption in period 1, while for those in the treatment one it comes at the expense of period 2 consumption, which is discounted by $\beta\delta$. Furthermore, comparing equations 3 and 6, we see that whether the optimal donation in treatment one or the optimal doantion in the control group is higher depends on the values of β and δ. Since the empirical literature (e.g., Ashraf et al., 2006;

Meier and Sprenger, 2010) has shown that the proportion of people who are present-biased or time consistent is large compared with the share of future-biased individuals, we expect $\beta\delta$ to be less than one. Therefore, we hypothesize that the donations in the *commit today and donate later* treatment are higher than in *donate today.*

Hypothesis 1: Mean donations are higher in the "commit today and donate later" treatment (Treatment one) than in the "donate today" group (control group).

People make intertemporal choices about private consumption and donations, which implies that the present value of the donations and forgone consumption depends on the time preference of individuals in general and whether they are present or future-biased in particular. For individuals in treatment one that are time-consistent individuals ($\beta = 1$) and have a discount factor of 1 ($\delta = 1$), the optimal levels of donations and private consumption in equation 6 will be the same as the one in the control group.

$$d^{*1} = d^{*2} = \frac{(\gamma - 1) + 2\alpha\overline{d}}{2\alpha}, \quad x^{*1} = x^{*2} = \frac{2c(E - \overline{d}) - (\gamma - 1)}{2\alpha},$$

However, for a given discount factor δ, comparing equations 6 and 3, we hypothesize that the mean donation is higher for present-biased than for non-present-biased individuals in treatment one.

Hypothesis 2: For a given discount factor, the mean donation for present-biased subjects in Treatment one is larger than the mean donation for subjects in the same treatment who are not present-biased, and the mean donation for future-biased individuals in Treatment one is smaller than the mean donation for subjects in the same treatment who are not future-biased

So far we have presented the utility maximization problem for individuals in the control group and treatment one, but the maximization problem for those in treatment two is different because of two additional features: inviting subjects to make a pledge in period 1 and then allowing them

to change the pledge and donate a different amount in period 2. Hence, the utility maximization problem in treatment two can be seen as a two-stage sequential design where individuals are assumed to use backward induction to decide on the optimal levels of pledges and donations. First, individuals decide or guess the optimal donation levels in period 2 for a given pledge level. Second, individuals determine the pledge level in period 1 based on the actual donation obtained in the first stage.

In the first stage of the maximization process (period 2), subjects are reminded about the amount they pledged (P) in period 1 and then they decide on actual donations (d^2_{T2}). In period 2, the utility function for subjects in treatment two has four elements. The first term represents the utility obtained from consumption of private good (x^2_{T2}), while the second and third elements are associated with actual donations made in period 2. The subjects are expected to experience warm glow when donating in period 2 (γd^2_{T2}) and disutility from deviating from the pledge $[\theta(P - d^2_{T2})]$. However, in the same period they also experience disutility for deviating from the some reference donation level, which is represented by $[\alpha(d^2_{T2} - \overline{d})^2]$. As a result, in period 2, the utility maximization problem is given as

$$\max_{x^2_{T2}, d^2_{T2}} \quad x^2_{T2} + \gamma(d^2_{T2}) - \alpha(d^2_{T2} - \overline{d})^2 - \theta(P - d^2_{T2})^2$$

$$\text{subject to} \quad x^2_{T2} + d^2_{T2} = E^2$$

The first order conditions are:

$$\begin{aligned} 1 &= \lambda_2 \\ \gamma - 2\alpha(d^2_{T2} - \overline{d}) + 2\theta(P - d^2_{T2}) &= \lambda_2 \\ x^2_{T2} + d^2_{T2} &= E \end{aligned}$$

The optimal levels of donations (d^2_{T2}) and a composite private good (x^2_{T2}) as a function of the pledge (P) are:

$$d^2_{T2} = \frac{\gamma - 1 + 2\alpha\overline{d} + 2\theta P}{2(\alpha + \theta)}, \quad x^2_{T2} = \frac{2E(\alpha + \theta) - (\gamma - 1 + 2\alpha\overline{d} + 2\theta P)}{2(\alpha + \theta)} \tag{7}$$

In the second stage of the utility maximization process (period 1), based on the optimal donation level obtained from period 2, subjects decide on the optimal pledge level. The utility function in this stage can be seen as having two main components. The first component has all the elements of the utility function in period 2, which are shown above, but in period 1 they are discounted by $\beta\delta$. The second component is a new element in the utility function in period 1, and it emanates from a benefit that an individual is assumed to experience by making a pledge, which is represented by $[\eta P]$. By pledging to give a higher amount than they would actually donate, subjects would be able to get utility by signaling to themselves that they are generous individuals . Therefore, the utility maximization function in period 1 is expressed as:

$$\max_{P} \quad \beta\delta[x^2_{T2} + \gamma(d^2_{T2}) - \alpha(d^2_{T2} - \overline{d})^2 - \theta(P - d^2_{T2})^2] + \eta P$$

By maximizing the above utility function, subjects in treatment two determine the optimal pledge levels (P^*) as a function of the expected optimal donation level, and it is given as:

$$P^* = \frac{\eta}{2\beta\delta\theta} + d^{2*}_{T2} \tag{8}$$

Substituting equation 7 into equation 8, we can obtain the optimal pledge level expressed as a function of the parameters.

$$P^* = \frac{\gamma - 1}{2\alpha} + \overline{d} + \frac{\eta(\alpha + \theta)}{2\beta\delta\theta\alpha} \tag{9}$$

Substituting the optimal pledge level in equation 9 in to 8, the optimal donation (d_2^*) in period 2 can be expressed as

$$d_{T2}^{*2} = \frac{\gamma - 1}{2\alpha} + \overline{d} + \frac{\theta\eta}{2\beta\delta\alpha} \tag{10}$$

However, time-consistent individuals know themselves and can predict their behavior in period 2 with certainty. Thus, η is assumed to be zero, which indicates that self-signaling from making a pledge will not produce any additional benefit. For time-consistent individuals, the optimal pledge and donation level is given as:

$$P^* = d_{T2}^{*2} = \frac{\gamma - 1}{2\alpha} + \overline{d} \tag{11}$$

We compare equations 6 and 3 with equation 9 to compare the pledge with the donations in the other treatments. These comparisons are the basis for the third hypothesis, which predicts that the mean pledge in treatment two is higher than the mean donation in the control group and treatment one.

Hypothesis 3: The mean pledge in the "revise pledge and donate later" treatment is higher than the mean donation in both the "donate today" group and the "commit today and donate later" treatments.

Our fourth hypothesis is based on the comparison of the optimal donations in treatment two and the control group from equations 10 and 3. All the expressions in the two equations are the same except that equation 10 has an additional term, $(\theta\eta/2\beta\delta\alpha)$. Since all parameters are assumed to be greater than zero, the additional expression in treatment two's utility function is also positive. Therefore, we hypothesize that the mean donation is higher in treatment two than in the control group. The intuition for the fourth hypothesis is that the pledges are assumed to be higher than actual donations, and individuals want to minimize the deviation from the pledge to reduce the cost of deviating from their pledge, which drives donations to be higher in treatment two than the case with no pledge (the control group).

Hypothesis 4: The mean donation is lower in the "revise pledge and donate later" treatment than in mean donation in the "donate today"group.
On the other hand, whether the mean donation in treatment two is greater or smaller than the mean donation in treatment one depends on coefficients of various elements in the utility function. In treatment two, the additional term $\theta\beta\delta(P - d_{T2}^2)$ in the utility function drives donations in treatment two to be higher than donations in treatment one. But the utility from private consumption is higher in treatment two than in treatment one because it is discounted by δ in treatment one. This implies that donations might be higher in treatment one. Therefore, whether the mean donation in treatment two is greater or smaller in treatment one depends on values of θ, η, the discount factor (δ), and the present bias parameter (β).

2.5 Description of Sample

The participants in the experiment were students at the College of Business and Economics, Addis Ababa University. They were recruited by means of an invitation to participate posted on a number of department bulletin boards. We used a lottery conducted publicly to randomly select 460 participants from the 608 students who had expressed their interest in participating. Of the 460 selected students, 454 ended up participating in the first round. In the second round, we had an attrition of 3%, reducing the sample in this round to 440 students. In the third round, only three students did not show up, implying an attrition rate of 0.6%. In total, 17 students dropped out over the course of the three rounds, corresponding to an attrition rate of 3.7%.[13] In the analysis, we only include the 437 subjects who participated in all three rounds and for whom we have complete information. The reason for this is that failure to participate in the second round obviously resulted in a lack of donation information and failure to participate in the last round prevented the collection of important background data. Table 1 provides detailed descriptions

[13]In each round, we texted the schedule to each participant plus a reminder to be on time. Participants were also informed that they could only participate if they arrived according to the schedule texted to them.

and definitions of the variables used in the analysis, and Table 2 shows the descriptive statistics of the participants included in the analysis.

The average age of our participants was 21 years, and 82% were men[14]. Regarding distribution across academic disciplines, 32%, 21%, 20%, and 26% belonged to the departments of economics, public administration, management, and accounting and finance, respectively. Since we wanted our subjects to be as representative of the general population as possible, we focused on students who were going to enter the job market soon. Sixty-seven percent of the participating students were in their third year and final year. In addition, the subjects' average monthly income/allowance was 498 birr (18.2 USD).

We asked the participants about their risk attitudes and stated trust in charity organizations. We measured risk attitude using a validated general risk question adopted from Dohmen et al. (2011).[15] We asked the participants to state their willingness to take risks "in general" on a 0–10 scale where 0="completely risk averse" and 10="completely risk taker." Based on this measure, the average stated risk attitude was 5.5. As for the trust question, subjects stated how much they trust charity organizations on a 1–5 scale, where 1="does not trust at all" and 5="trust completely." Using this scale, the average stated trust in charity organizations was 2.7.

In terms of exposure to and previous contact with the Mekedonia, 18% of the subjects had physically visited the organization and 46% had given donations to it prior to the experiment. Given that the charity organization sends at least one text message per month to almost all active cellphone users in Ethiopia (around 20 million) asking for donations using phone credits, the fairly large number of subjects who had made previous donations is not surprising.[16]

[14]Eight-one percent of all regular undergraduate students at the College of Business and Economics were men at the time of the experiment.

[15]Dohmen et al. (2011) show that among different measures of risk attitudes, the general risk question is the best in explaining observed risky behavior.

[16]In an effort to help the charity organization, the state-run Ethio Telecom, which is the sole provider of telecommunication services in the country, allowed the charity organization to send text messages to its customers free of charge. After receiving

Subjects were randomly assigned to one control group and two treatment groups. The actual treatment effects can only be accurately measured if the subjects in the different groups are similar. Table 2 provides the p-values mean differences test between the groups. We fail to reject the null hypothesis of equal means for all variables except risk attitude, age, number of days before withdrawal, and withdrawing money or not. Compared with the subjects in treatment one, those in the control group are more risk loving, and a larger proportion did not utilize the money at all. However, the differences in these three variables are only significant at the 10% level and as we control for these variables in the regressions, the effects will likely be small.[17]

the text, people could just text back stating the amount they wanted to send from their phone credit. The telecommunication provider then would transfer the collected money to the charity organization.

[17] If anything, these factors would reduce the "true" treatment effect and our findings can be taken as a lower bound.

TABLE 1: *Variable Description*

Variable	Variable Definition
Outcome variable	
Amount donated	Amount donated to Makedionia in birr
Key explanatory variable	
Treatment	Control group (Donate today), treatment 1 (Binding commitment today to donate later and treatment 2 (Revisit previous pledge + donate later)
Time preference variables-Experimental measures	
Time consistent	1 if respondent is time consistent; 0 otherwise
Present-biased	1 if respondent is present-biased; 0 otherwise
Future-biased	1 if respondent is future-biased; 0 otherwise
Discount factor	Experimentally measured discount factor between 0 and 1
Multiple switch	1 if the respondent switched more than once in the time preference experiment; 0 otherwise
Monetary behavior in the field	
Amount sent	Amount sent to participants in birr
Amount utilized	Amount used by participants in birr
No. of days before utilizing money	The number of days the money remained in the respondent's cellphone account before withdrawal
Did not withdraw money	1 if the respondent did not withdraw money within three months of deposit into account; 0 otherwise
Bought mobile air time	1 if respondent bought mobile airtime with the money in their mobile account; 0 otherwise
Withdrew cash	1 if respondent withdrew the money in their mobile in cash; 0 otherwise
Socio-economic variables	
Age	Age of the respondent in years
Sex	1 if respondent is male; 0 otherwise
Orthodox	1 if religion is Orthodox Christian; 0 otherwise
Muslim	1 if religion is Muslim, 0 otherwise
Protestant	1 if religion is Muslim; 0 otherwise
Other religion	1 if religion is other religion/No religion; 0 otherwise
Second year student	1 if the respondent is a second year student; 0 otherwise
Third year student	1 if the respondent is a third year student (Graduating class); 0 otherwise
Economics	1 if respondent is in Economics department; 0 otherwise
Accounting	1 if respondent is in Accounting department; 0 otherwise
Public Administration	1 if respondent is in Public Administration; 0 otherwise
Management	1 if respondent is in Management; 0 otherwise
Monthly income (in birr)	Monthly allowance/income of subjects in birr
Trust in charity organ	Stated trust in charity organizations from 1 to 5
Risk	Stated own risk perception from 0 to 10
Visited charity before	1 if the respondent had ever visited Mekedonia before participating in the experiment; 0 otherwise
Donated to charity before	1 if the respondent had ever visited Mekedonia before participating in the experiment; 0 otherwise

TABLE 2: *Summary statistics and mean comparisons between groups*

Variable	Obs	Full sample		Control		Treatment 1		Treatment 2		Difference (P-values)		
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	(C-T1)	(C-T2)	(T1-T2)
Age	437	21.82	1.87	22.05	2.57	21.64	1.37	21.74	1.20	0.09*	0.20	0.49
Male	437	0.82	0.38	0.84	0.37	0.80	0.40	0.82	0.39	0.43	0.62	0.78
Economics	437	0.32	0.47	0.31	0.46	0.30	0.46	0.37	0.49	0.83	0.25	0.19
Accounting	437	0.26	0.44	0.25	0.44	0.29	0.46	0.25	0.43	0.48	0.92	0.44
Public Administration	437	0.21	0.41	0.22	0.42	0.24	0.43	0.18	0.38	0.73	0.31	0.19
Management	437	0.20	0.40	0.22	0.41	0.17	0.38	0.20	0.40	0.36	0.81	0.52
Monthly income (in birr)	436	497.77	397.48	508.88	394.94	509.53	352.86	472.87	442.16	0.99	0.46	0.45
Third year student	437	0.67	0.47	0.67	0.47	0.72	0.45	0.62	0.49	0.33	0.35	0.07*
Trust in charity organ	437	2.71	1.20	2.78	1.16	2.68	1.15	2.66	1.28	0.44	0.37	0.87
Risk	436	5.51	2.64	5.73	2.32	5.19	2.68	5.59	2.94	0.06*	0.65	0.24
Visited charity before	437	0.18	0.38	0.15	0.36	0.19	0.39	0.19	0.39	0.44	0.42	0.98
Donated to charity before	437	0.46	0.50	0.51	0.50	0.45	0.50	0.42	0.50	0.28	0.13	0.67
Orthodox	437	0.65	0.48	0.64	0.48	0.61	0.49	0.71	0.46	0.63	0.19	0.08*
Muslim	437	0.14	0.35	0.14	0.35	0.17	0.37	0.11	0.31	0.56	0.40	0.17
Protestant	437	0.19	0.39	0.19	0.39	0.21	0.41	0.18	0.38	0.59	0.82	0.46
Other religion	437	0.02	0.14	0.04	0.19	0.01	0.12	0.01	0.09	0.23	0.09*	0.57
Discount factor (Today vs 2 weeks)	437	0.63	0.22	0.64	0.23	0.64	0.21	0.63	0.22	0.95	0.75	0.87
Discount factor (2 vs 4 weeks)	437	0.62	0.21	0.61	0.22	0.63	0.20	0.64	0.21	0.42	0.28	0.65
Time consistent	437	0.50	0.50	0.50	0.50	0.49	0.50	0.50	0.50	0.80	0.68	0.58
Present-biased	437	0.18	0.39	0.16	0.37	0.19	0.39	0.20	0.40	0.53	0.77	0.89
Future-biased	437	0.32	0.47	0.34	0.48	0.33	0.47	0.30	0.46	0.81	0.50	0.63
Multiple switch	437	0.08	0.27	0.10	0.31	0.07	0.26	0.06	0.24	0.33	0.15	0.64
Amount sent (in birr)	437	70.38	14.18	69.63	15.12	70.51	13.10	71.13	14.13	0.59	0.38	0.70
Amount utilized	437	61.51	24.52	59.04	25.72	63.70	22.39	62.23	25.02	0.10	0.28	0.61
No. of days before withdrawal	437	4.26	14.99	5.99	18.69	2.54	9.64	3.94	14.38	0.05*	0.30	0.34
Did not use money	437	0.02	0.15	0.04	0.19	0.01	0.09	0.02	0.15	0.09*	0.45	0.31
Bought mobile air time	437	0.15	0.36	0.14	0.34	0.15	0.36	0.16	0.37	0.69	0.55	0.85
Withdrew cash	437	0.85	0.36	0.86	0.34	0.85	0.36	0.84	0.37	0.69	0.55	0.85

Note: The last three columns present p-values for mean comparison using t-tests. At the time of the experiment (Spring 2018), USD 1=27.3 birr. Subjects who switched multiple times in the time preference experiment are included in the mean comparison, and their first switching point was taken to compute their discount factor.

3 Results

In this section, we first discuss the results from the donation experiment. Then, we present findings on the link between subjects' time preference and their donations.

3.1 Donation Decisions

Figure 2 presents the average donation in birr for each group as well as the average pledge made by participants in treatment 2. We also computed the share of subjects who donated a positive amount in each treatment group. When subjects were asked to donate "today," 83% donated a positive amount and the mean donation was 13.9 birr, corresponding to about 13.9% of their earning. Among the subjects who made a binding commitment to donate later, i.e., T1, 84% donated a positive amount and the mean donation was about 19% of their earnings. In the last group, T2, where subjects made a revisable pledge "today" but the final donation payment was made two weeks later, 80% donated a positive amount and the average donation was 16.1 birr.

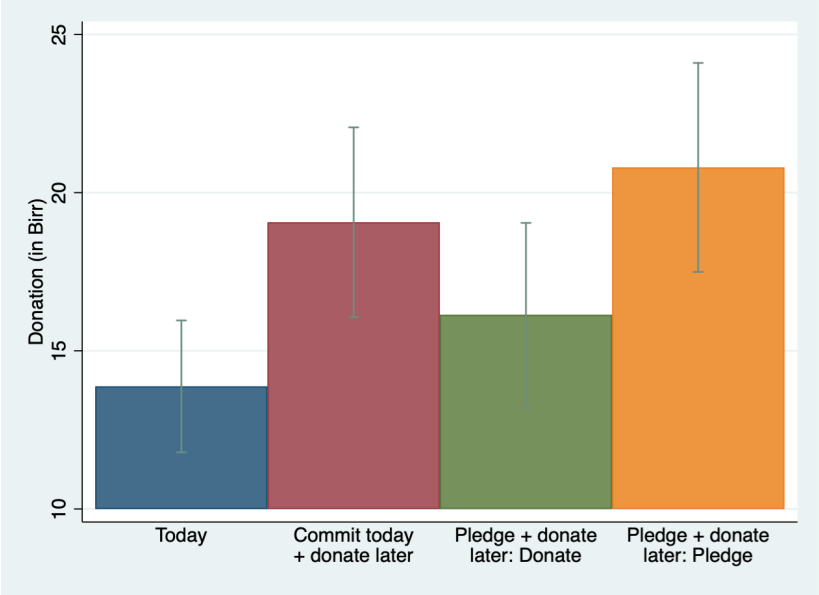

Figure 2: Mean donation in birr for each group, with a 95% confidence interval

To examine whether the observed differences in donations among the three groups are statistically significant, we use Mann-Whitney rank-sum and present the results in Table 3. Except for the difference in mean actual donation between the control group (asked to donate today) and T1 (those who made a binding commitment to donate later), no other mean differences are statistically significant. In addition to the statistical significance of the treatment effect, by looking at the absolute difference in mean donation among the groups, Table 3 also enables us to assess the economic significance. For instance, by giving subjects an opportunity to make a binding commitment to donate in two weeks (the future), it was possible to increase the actual donations by 37% compared with the average donation in the control group, making the effect both statistically and economically significant. This finding is in line with *Hypothesis 1*. In contrast, we do not find strong evidence for *Hypothesis 4*, as Table 3 shows that the mean donation is 2.2 birr higher in T2 ("revise pledge and donate") than in the control group (this difference is not statistically significant). Our results are well in line

with previous studies in developed countries that show that allowing respondents to commit themselves to making future donations increases donations compared with asking for donations to be made immediately. For example, by allowing donors to commit themselves to making donations two months later, Breman (2011) finds a 19% increase in amounts donated, while Andreoni and Serra-Garcia (2016) gave respondents the opportunity to commit to making donations after one week, and find a 47% increase in the proportion of people who donated a positive amount.

TABLE 3: *Differences in average donations among groups and pairwise comparison results*

Differences between groups	**Difference in birr**	**Z-value**	**P-value**
Donate today-Commit today and donate later	-5.18	-2.38	0.0173
Donate today-Pledge and donate later	-2.26	-0.733	0.4638
Commit today and donate later-Pledge and donate later	2.92	1.518	0.1290

Note: The pairwise comparisons were computed using the Mann-Whitney rank-sum test.

Our results, and previous research findings, show that providing an opportunity to have a binding commitment to make future donations increases the donation amounts in the first period compared with asking for donations to be made immediately. However, ex ante it is difficult to predict the long-run impact of such fund-raising mechanisms because once people make a pledge, they may want to revise their donation decision in the future periods, leading to lower donations in the long run. Thus, it is important to look into the effect of giving people the opportunity to change their past donation decisions. To this end, we analyze the revisable pledges and donation decisions in T2, where subjects had the opportunity to pledge an amount in the second round and then revise their pledges in the third round.

As shown in Figure 2, the mean pledged donation was 20.8 birr, which is 7 birr higher than the average donation made in the control group. Furthermore, using pairwise comparison we find that the amounts pledged in treatment two is larger and statistically significant than the donations

in both the control group and treatment one. Therefore, the evidence supports *Hypothesis 3*. Looking at the final donation decision further reveals that 63% of the subjects in treatment two confirmed their past pledge while 28% reduced and 9% increased the amount donated. As a result, the mean actual donation in this group is about 5 birr smaller than the mean pledged amount. A pairwise comparison of the pledges and actual donations using the Wilcoxon sign-rank test also indicates that the difference is statistically significant with a p-value of 0.0001.

It could be argued that the timing of the experiment may have influenced how the subjects behaved in the study. More specifically, if the experiment was conducted at a time when the students had just received money from their parents, or at a time when they had little money available, the donation behavior may have been influenced accordingly.[18] Nevertheless, in our study we expect these effects to be minimal or even non-existent. Further more, Table A.8 in the appendix suggest that the earnings from the time preference experiment do not influence the amount donated by respondents.

3.2 Time Preferences

Of the 437 subjects who participated in all rounds, 35 (8%) had multiple switching points and thus exhibited inconsistent behavior. For those who switched multiple times, we take the first switching point to the earlier payment and included these observations in our main analysis. Our main

[18] In our sample, the parents of 53% of the participants lived in rural areas and may therefore not be able to send money every month. Thus, we assume participants who only had parents living in urban areas could receive a monthly allowance. The first and second rounds were conducted one and two weeks after the week during which students usually receive their monthly allowances, respectively. Since participants in the *donate today* group and *commit today and donate later* made their donation decisions in the second round, we assume that their income outside the experiment had minimal effect. However, the time at which the third round was conducted lies in the week participants receive their monthly allowance. Therefore, for the 48 % of students who receive monthly allowance, we cannot rule out that the results observed in the third round of *revise pledge and donate later* could be influenced by participants' outside income.

findings remain robust to the exclusion of "multiple switchers" (these results are provided in the appendix).

In the near timeframe (timeframe 1), participants were asked to choose between 80 birr in two weeks and an increasing amount immediately. As 80 birr corresponds to slightly more than half a day's pay for fresh business graduates in the Ethiopian bank sector, we can assume that subjects gave sufficient thought to their choices. We elicit a 2-week discount factor and find it to be 0.63 in our sample on average, indicating that for our subjects, the value of 100 birr obtained after two weeks is equivalent to 63 birr acquired immediately. The average discount factor obtained in this study is low compared with in other studies that utilized similar experimental techniques. For instance, Meier and Sprenger (2010) report a monthly individual discount factor of 0.83 for U.S. residents, and Cassar et al. (2017) find a monthly discount factor of 0.74 in rural Thailand. In our sample, 18% of the subjects are classified as present-biased, while 32% are future-biased.

The percentage of individuals classified as present-biased in this paper (18%) is relatively low compared with previous findings in the literature, which range from 27 to 36%. However, a similar proportion of future-biased subjects has been documented previously. Meier and Sprenger (2010) find a higher percentage of future-biased (38%) individuals. For present-biased individuals, they find that the share is 28%, and Meier and Sprenger (2010) report rates of 9% and 36%, respectively. Cassidy (2018) corresponding figures for Pakistan are 29% for present-biased and 32% for future-biased, and in Ashraf et al. (2006) 27% were present-biased and 20% future-biased.

The experimental approach of measuring people's time preferences could potentially be influenced by borrowing and lending opportunities existing outside the experiment (Meier and Sprenger, 2010; O'Donoghue and Rabin, 2015). It can be assumed that depending on the interest rates in and outside of the experiment, individuals may engage in arbitrage. That is, if subjects can borrow money at a lower interest rate than the one offered in the experiment, they could follow an arbitraging strategy

of borrowing at a lower rate and getting more money later, i.e., borrow low-save high. In the case where the outside interest rate is higher than the one offered in the experiment, subjects may want to request the earlier payment and then invest or lend it at a higher interest rate in the outside market.

The lowest annual interest rate in the experiment is around 370% ($(80/75)^{24}-1$) and the highest annual interest rate in the country is 7.5%. Given the high interest rate offered in the experiment, we assume that participants can only follow one arbitrage strategy, which is borrowing from outside at a lower rate and choosing later payments in the experiment, resulting in a high saving rate in the experiment. If we assume that participants followed this strategy, we expect to observe a high level of patience and time-consistent individuals. In contrast, however, we observe individuals being highly impatient and a large proportion of participants exhibit time-inconsistent behavior. Therefore, although the time preference measure used in the study can theoretically be affected by the arbitrage behavior of participants, we believe it is highly unlikely.

3.3 Regression Results

We will now explore the treatment effect using regression models. First we will look at the link between experimentally elicited time preference of subjects and donations in different treatments. Table 4 presents the results. Then in Table 5, by splitting the sample into three groups, we investigate the differences in average donations made by time-inconsistent subjects. However, it should be noted that we only look at time-inconsistent behavior and measure subjects' discount factor with regard to money, not donations. The first model in Table 5 only includes the treatment dummies, and the results reaffirm the descriptive statistics, where donations are higher both when individuals make a binding commitment immediately and donate later (T1) and when they make a revisable pledge immediately and make the final donation decision later. In particular the mean donation in the commit today but donate later treatment is higher than the mean donation in the control group (donate today), and the difference is

statistically significant. Looking at the economic significance, the increase in mean donation in the commit today and donate later treatment is 5 birr, which is equivalent to 37% of the mean donation (13.9 birr) in the donate today treatment. In contrast, the average donation in treatment two, where subjects are asked to make a pledge immediately and make a final donation decision later, is not statistically different from that in the donate today.

The results from model 2, where we include donor characteristics and time preferences, albeit being statistically insignificant, show that the coefficients of the interaction terms between the discount factors and the treatment variables are large in magnitude. We also examine whether the effects are different for different treatments. In other words, we assess whether the actual donations of subjects in both the donate later with commitment and those who had a chance to pledge today and revise later differ based on the experimental measure of people's impatience. The results indicate that more patient subjects do not respond differently than less patient subjects when asked to donate today or later.

In model 3, we investigate the interaction between the treatment and measures of hyperbolic discounting. By controlling for the discount factor, we are able to see the effect of being present- or future-biased regardless of a person's actual discount factor. Similar to model 2, our findings reveal that, compared with the average donation of time-inconsistent individuals, the donations of present-biased or future-biased people do not differ significantly in each treatment. Thus, our hypothesis that the mean donation by present-biased individuals is higher in treatment one, i.e., *Hypothesis 2*, is not supported by the data. Furthermore, the results in models 2 and 3 do not show the magnitude of the treatment effect, so we compute the marginal effects of both models and present the result in Table A.2 of the appendix. As can be seen in that table, the marginal effect of Treatment 1 on donation is significant and similar in magnitude in all the three models.

TABLE 4: *Actual donations and experimentally elicited time preference measures*

Variables	**(1)**	**(2)**	**(3)**
Treatment 1	5.115***	-2.684	6.855**
	(1.850)	(6.758)	(3.021)
Treatment 2	2.234	4.160	0.048
	(1.819)	(5.840)	(2.648)
Discount factor		-11.862*	-5.121
		(7.054)	(4.267)
Treatment 1#Discount factor		13.117	
		(9.537)	
Treatment 2#Discount factor		10.223	
		(8.457)	
Time consistency (Base group=Time consistent)			
Present-biased			-1.946
			(2.554)
Future-biased			-2.078
			(2.304)
Present-biased#Treatment 1			-3.463
			(4.848)
Present-biased#Treatment 2			3.366
			(4.631)
Future-biased#Treatment 1			-1.579
			(3.914)
Future-biased#Treatment 2			5.475
			(3.749)
Constant	13.950***	-18.574**	-22.561***
	(1.060)	(9.000)	(8.238)
Observations	435	435	435
R-squared	0.017	0.165	0.169
Controls	NO	YES	YES

Note: The dependent variable in all columns is actual donation in birr. Covariates include age, gender, department, year at the university, religion, monthly income, risk attitude, dummy for multiple switching, trust in charity organizations in general, and past visits and donations to Mekedonia. In all columns, we used OLS regressions with robust standard errors. Participants who switched multiple times in the time preference experiment are included in the analysis. *** p<0.01, ** p<0.05, * p<0.1

In summary, the regression results in Table 4 reveal that compared with asking people for immediate donations, which is the dominating fundraising strategy for most charity organizations in developing countries, asking donors to make a binding commitment immediately to make a future donation increases the size of the donations. However, the donations were not found to differ significantly between participants who were given an opportunity to make a non-binding pledge today and finalize the donation decision later and those who were asked to donate immediately. All three specifications show that there is no significant heterogeneity based on people's time preferences. In other words, our findings provide evidence that the fundraising strategy of allowing donors to commit today to donate in the future does not work more effectively on neither impatient nor present-biased individuals than asking for donations to be made immediately.

It could be argued that individuals who are present- or future-biased differ from time-consistent ones. Thus, we now split the sample into three groups and investigate whether the donations differ across treatments for time-consistent subjects (*Hypothesis 2*). Table 5 shows that for present-biased subjects, the donations are not statistically different across all groups.[19] A similar result is found for those who are future-biased when we include other covariates. Therefore, the results in both Table 4 and Table 5 lead us to reject *Hypothesis 2*.

[19]Given the low statistical power, the results from Table 5 can only be taken as suggestive.

TABLE 5: *Actual donations and time inconsistent measures*

	Present-biased		Future-biased		Time consistent	
Variable	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Treatment 1	5.000	-3.879	4.402*	5.601	5.758*	-0.844
	(3.428)	(8.166)	(2.544)	(14.419)	(3.099)	(10.109)
Treatment 2	5.788	3.577	4.866*	10.017	-0.670	-7.070
	(4.258)	(6.613)	(2.765)	(11.727)	(2.749)	(9.068)
Discount factor		-1.130		-4.542		-17.238
		(10.242)		(9.869)		(10.488)
Treatment 1 #Discount factor		12.970		-1.033		12.480
		(18.373)		(19.664)		(14.093)
Treatment 2#Discount factor		-0.180		-7.604		9.882
		(13.746)		(16.814)		(13.563)
Constant	11.731***	31.613	12.709***	3.293	15.525***	-26.111*
	(1.357)	(29.046)	(1.456)	(17.428)	(1.825)	(15.260)
Observations	79	79	140	140	216	216
R-squared	0.026	0.413	0.030	0.216	0.024	0.232
Controls	NO	YES	NO	YES	NO	YES

Note: The dependent variable in all columns is actual donation in birr. Covariates include age, gender, department, year at the university, religion, monthly income, dummy for multiple switching, trust in charity organizations, and previous visits and past donations to Mekedonia. In all columns, we used OLS regressions with robust standard errors. Participants who switched multiple times in the time preference experiment are included in the analysis. *** p<0.01, ** p<0.05, * p<0.1

3.4 Robustness Checks

We conducted several robustness checks to investigate the robustness of our key findings. First, we set the discount factor of subjects with multiple switches in the time preference analysis to zero and compared it with the original discount factor. Second, we examined the effect of excluding subjects with multiple switches from the analysis. The findings show that our main results are robust to the inclusion of multiple switchers and to changing the subjects' discount factor to zero. Third, we restricted the sample to only those who withdrew money and did not switch multiple times in the time preference experiment and ended up with results that are similar to those of the main analysis. Fourth, using a t-test, we conducted a mean comparison of donations for each group by specific sessions subjects attended, and the results show that there are no significant differences in donations based on the experimental session attended. Similarly, a non-parametric test using the Mann-Whitney rank-sum tests rejects the pairwise differences in donations by session attended. The results are available upon request.

For subjects in treatment two, there was a 2-week period between the second and third round. Thus, it is plausible that those in treatment two might have obtained information about the pledge or donations made by others and then used this information to revise their pledge upward or downward. Assuming that participants might have obtained donation information from classmates and other students at their department, we examine the influence of this information using two approaches. First, we cluster the standard errors by home department and year at the university, yielding eight clusters. Table 6 presents the results. Given the small number of clusters, we use the wild cluster bootstrapped standard errors suggested by Cameron et al. (2008). Table 6 shows that clustering the standard errors did not change our main finding that the mean donation is not statistically different between treatment two and the control group.

TABLE 6: *Effect of Treatment 2 on actual donations*

Variables	**(1)**	**(2)**	**(3)**	**(4)**
Treatment 2	2.234	2.234	2.234	2.234
	(1.819)	(2.025)	(2.104)	(3.020)
Constant	13.950***	13.950***	13.950***	13.950***
	(1.060)	(1.078)	(1.152)	(0.000)
Observations	435	435	435	435
R-squared	0.017	0.017	0.017	0.017

Note: In all columns, we present coefficient of OLS regressions, and the dependent variable is actual donation in birr. Column (1) presents robust standard errors in parentheses while for column (2–4), the standard errors are clustered by department and years at the university. Column (2) shows bootstrapped clustered standard errors. Column (3) shows adjusted clustered standard errors, as suggested by Cameron et al. (2011). Column (4) shows wild clustered bootstrapped standard errors. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Second, we include the average donation of others and examine whether this information influenced the donations made in the third round. In order to be exhaustive in our analysis, we consider that participants can potentially obtain information from any of the three types of groups: i) same department and year regardless of treatment group, ii) same department and year and those in treatment two, and iii) same department, year, and experiment session. In Table A.4, we examine the influence of average donations from each category on own donations for subjects in treatment two. As shown in the appendix Table A.4, the results show that the average donations by others are not statistically significant in explaining own donations. Furthermore, in Table 7, we examine whether the donation and pledges made by others influence the treatment effect and our main findings by using the same specification as in Table 4 and including the donations made by others. As shown in Table 7, when we account for the pledge and donations made by others, the effect of Treatment 2 becomes weaker but remains insignificant. On the other hand, columns (2) and (3) show that own donations and donations by others are negatively correlated, indicating that the contributions made by others act as a substitute for own donations.

TABLE 7: *Marginal effect of actual donation and experimentally elicited time preference measures*

Variables	**(1)**	**(2)**	**(3)**
Treatment 1	5.117***	4.209**	4.284**
	(1.854)	(1.695)	(1.680)
Treatment 2	2.239	1.385	1.453
	(1.828)	(1.642)	(1.645)
Mean donation by others	0.081	-9.372***	-9.521***
	(0.295)	(1.380)	(1.398)
Dummy for multiple switch		-2.723	-3.002
		(2.577)	(2.658)
Discount factor		-2.881	-3.084
		(3.654)	(3.926)
Present-biased			-2.453
			(1.923)
Future-biased			-1.727
			(1.520)
Observations	435	435	435
Controls	NO	YES	YES

Note: The dependent variable in all columns is actual donation in birr. Covariates include age, gender, department, year at the university, religion, monthly income, risk attitude, trust in the charity organizations, and previous visits and past donations to Mekedonia. In all columns, we used OLS regressions and present the marginal effect coefficients of the treatments. *** p<0.01, ** p<0.05, * p<0.1

As our treatments involve decisions about future income and donation streams, risk attitudes may influence the subjects' donation decisions. In order to assess whether subjects with different risk attitudes react to the treatments differently, we include an interaction term between the general risk question and the treatment. The findings show that risk attitudes do not confound our results, and our findings remain robust to the inclusion of an interaction term between treatment and the risk attitudes of subjects, as shown in Table A.5 of the appendix.

In the main analysis, we used experimentally elicited time preferences of individuals. We check the robustness of our result using the monetary withdrawal behavior as an alternative indicator of subjects' time preferences. The alternative measure comes from administrative bank data on the time preference earnings sent to subjects. The administrative data contain information on three aspects: i) whether subjects withdrew the money in cash or used it to by cellphone airtime, ii) the amount withdrawn from the cellphone account in the first transaction or the value of airtime bought, and iii) the number of days the money remained in the account. In Table 8, we investigate whether the amount donated varies significantly between subjects with differing monetary withdrawal behaviors in the field.

In model 1, we include an interaction between the treatment and a categorical variable for the number of days the money remained in the account before it was either withdrawn in cash or used to buy airtime. Out of the six interaction terms shown in model 1, only two are significant and they do not have the expected sign; people who did not use the money sent to them for one or two days donated lower amounts than did subjects in the control group who withdrew the money the same day.

In model 2, we use a continuous variable measuring the number of days before withdrawal. The results show that the interaction term between number of days and treatment is marginally significant at the 10% level. Subjects who are more patient donated more in treatment one but less in treatment two. A third measure of impatience that we explore is the proportion of money withdrawn by subjects, which is presented in model 3. We interact the treatment with proportion of money withdrawn by subjects, and the interaction term for treatment one is insignificant while for treatment two it is positive and marginally significant at 10%.

TABLE 8: *Monetary withdrawal behavior in the field and actual donations*

Variables	**(1)**	**(2)**	**(3)**
Treatment 1	7.454***	5.453***	10.346*
	(2.460)	(1.869)	(6.031)
Treatment 2	7.012***	3.475*	-4.671
	(2.312)	(1.773)	(4.039)
Trust in charity organizations	1.251**	1.301**	1.272**
	(0.633)	(0.589)	(0.625)
Monthly income (in birr)	0.008***	0.007***	0.008***
	(0.002)	(0.002)	(0.002)
Risk attitude	0.173	0.260	0.219
	(0.284)	(0.297)	(0.289)
Have visited Makedonia before	1.917	1.825	1.961
	(2.152)	(2.235)	(2.207)
Have donated to Makedonia before	2.809*	2.879**	2.926**
	(1.442)	(1.443)	(1.425)
Didn't withdraw money	-5.313	-20.644	-5.424
	(4.833)	(19.083)	(5.245)
Amount sent	-0.030	-0.021	
	(0.075)	(0.061)	
Mobile card	1.421	2.446	0.591
	(2.314)	(2.140)	(3.041)
No. of days before the first withdrawal (Base group=Same day)			
One day	2.130		
	(3.152)		
Two days	2.776		
	(2.865)		
$\geq$ Three days	4.581		
	(3.919)		
One day#Treatment 1	-4.033		
	(4.787)		
One day#Treatment 2	-8.385**		
	(4.087)		
Two day#Treatment 1	-6.334		
	(4.606)		
Two days#Treatment 2	-13.189***		
	(4.479)		
$\geq$ Three days#Treatment 1	-1.549		
	(5.688)		
Three days#Treatment 2	-6.593		
	(5.802)		
No. of days before withdrawal		0.236	
		(0.246)	
Treatment 1#No. of days before withdrawal		0.251*	
		(0.134)	
Treatment 2#No. of days before withdrawal		-0.187*	

Continued on next page

Table 8 – *Continued from previous page*

Variables	**(1)**	**(2)**	**(3)**
		(0.096)	
Proportion of money withdrawn			-4.747
			(4.821)
Treatment 1#Proportion of money withdrawn			-4.948
			(6.323)
Treatment 2#Proportion of money withdrawn			8.344*
			(4.415)
Constant	-28.502***	-26.726***	-24.322***
	(8.988)	(8.761)	(8.635)
Observations	435	435	435
R-squared	0.181	0.184	0.169

Note: In all columns, we present coefficient of OLS regressions with robust standard errors. The dependent variable in all columns is actual donations in birr, and participants who switched multiple times in the time preference experiment are included in the analysis. *** p<0.01, ** p<0.05, * p<0.1

4 Conclusions

Charitable organizations support the lives of millions of people in developing countries. The funds mainly come from donors in developed countries, but fluctuate in size, hence raising concerns about the sustainability of the supported programs. Increasing local donations is one avenue to address this sustainability issue. Despite the huge interest in increasing local donations, not enough attention has been given to designing effective fundraising schemes in developing countries.

Previous research in the area of donations has mainly investigated donation behavior in developed countries. However, little attention has been given to intertemporal donation decisions and the underlying behavior in developing country contexts. This study aims to contribute to the literature by examining the time preferences and donation behavior of subjects in a dynamic setting that involves more than one period. We conducted a three-round experiment involving university students in Ethiopia. In the first round, we elicited the time preferences of participants in an incentive-compatible manner. In the second and third rounds, we conducted the donation experiment. We followed a between-subject design where subjects were randomly assigned to one of three groups: *donate today, commit today and donate later, and pledge today and donate later.*

Our findings show that asking donors to commit to donate later increases donations by 37% compared with asking donors to donate immediately, which is the existing fundraising strategy for most charity organizations. The effect found in our study is almost twice larger than the effect size found in previous studies such as Breman (2011). Moreover, the option of offering donors to make a revisable pledge and make a final donation decision later did not result in a statistically significant difference in donations compared with the control group, i.e., donating today. Further, we did not find any statistically significant correlation between subjects' time preferences and donation behavior when the payment date was extended. In particular, we find that present-bias does not explain the treatment effect. Our findings suggest that instead of asking for donations

immediately, charity organizations in developing countries can increase donations by asking people for a binding commitment to make future donations. Another implication of our results is that the strategy of offering potential donors an opportunity to make binding commitments to make future donations can be applied across the board regardless of the donors' time preferences.

A Appendix

A.1 Example of a time preference instruction and decision sheet

In this task you will make a number of choices between two options labelled Option A (on the left) and Option B (on the right). We will present you with 16 of these decision situations. The options will only differ in terms of donation amounts and payment dates.

The decisions you have to make are numbered from 1 to 16. You will have a 1-in-16 chance of being paid for one of these decisions. The selection is made by drawing a strip of paper from a ball containing strips of paper numbered from 1 to 16. When you make your choices, you will not know which decision will be randomly selected for payment. Therefore, you should make each decision carefully as it could determine your payment.

The money you earn from this part of the experiment will be paid to you in cash after the experiment. The money will be transferred to you on the date stated in your preferred option. Starting on the day you receive a text message from Commercial Bank of Ethiopia (CBE), you will be able to collect the money from the CBE Birr agent found at the College of Business and Economics (CoBE) or any other CBE Birr agent or any CBE branch. This study is carried out in collaboration with the economics department at Addis Ababa University, which also guarantees all payments. You will be given a confirmation letter stating that the money that will be transferred to you, as well as the payment date. If you chose to receive the money today n the randomly selected decision, then it will be paid out on the same date after the experiment. However, if you chose to receive the money in the future, then you will be able to collect the money starting on the day specified in your choice, but not prior to this date.

In order for you to understand the task better, let me explain by using an example. After you have selected your preferred option for each of the 16

decisions, if Decision 1 is randomly selected and your choice was Option B (that is, you chose 80 birr in two weeks instead of 10 birr today), then the confirmation letter you will receive today after the experiment will state that 80 birr will be transferred to you in two weeks. If, however, you chose Option A (10 birr today instead of 80 birr in two weeks), your confirmation letter will state that 10 birr will be transferred to you today. Thus, you will be able to collect the money starting today.

Let's consider another situation, where Decision 8 is randomly chosen and your preferred choice is Option A. That is, you chose to receive 75 birr today instead of 80 birr in two weeks. Then you will be given a confirmation letter stating that 75 birr will be transferred to you today after the experiment. Thus, you will be able to collect the money starting today. However, if you chose Option A (80 birr in two weeks instead of 70 birr today), then you will be given a confirmation letter stating 80 birr will be transferred to you in two weeks. You will be able to collect the money starting in one week.

Let's consider one more situation, where Decision 16 is randomly chosen and your preferred choice is Option B. That is, you chose to receive 80 birr in four weeks than 70 birr in two weeks. Then, you will receive a confirmation letter stating that you will be able to collect the 80 birr in four weeks. If, however, you chose Option A, 70 birr in two weeks rather than 80 birr in four weeks, then you will be given a confirmation letter stating that 70 birr will be paid to you in one week. Please indicate for each of the following 16 decisions whether you would prefer the smaller payment in the near future or the bigger payment later.

Time preference decision sheet

Please indicate for each of the following 16 decisions, whether you would prefer the smaller payment in the near future or the bigger payment later.

Option A (TODAY) or Option B (IN 2 WEEK)

Decision (1): ○ 10 Birr guaranteed today - 80 Birr guaranteed in 2 weeks ○

Decision (2): ○ 20 Birr guaranteed today - 80 Birr guaranteed in 2 weeks ○

Decision (3): ○ 30 Birr guaranteed today - 80 Birr guaranteed in 2 weeks ○

Decision (4): ○ 40 Birr guaranteed today - 80 Birr guaranteed in 2 weeks ○

Decision (5): ○ 50 Birr guaranteed today - 80 Birr guaranteed in 2 weeks ○

Decision (6): ○ 60 Birr guaranteed today - 80 Birr guaranteed in 2 weeks○

Decision (7): ○ 70 Birr guaranteed today - 80 Birr guaranteed in 2 weeks ○

Decision (8): ○ 75 Birr guaranteed today - 80 Birr guaranteed in 2 weeks ○

Option A (IN 2 WEEK) or Option B (IN 4 WEEKS)

Decision (9): ○ 10 Birr guaranteed in 2 weeks - 80 Birr guaranteed in 4 weeks ○

Decision (10):○ 20 Birr guaranteed in 2 weeks - 80 Birr guaranteed in 4 weeks ○

Decision (11):○ 30 Birr guaranteed in 2 weeks- 80 Birr guaranteed in 4weeks ○

Decision (12):○ 40 Birr guaranteed in 2 weeks - 80 Birr guaranteed in 4 weeks○

Decision (13):○ 50 Birr guaranteed in 2 weeks - 80 Birr guaranteed in 4 weeks○

Decision (14):○ 60 Birr guaranteed in 2 weeks - 80 Birr guaranteed in 4 weeks○

Decision (15):○ 70 Birr guaranteed in 2 weeks - 80 Birr guaranteed in 4 weeks○

Decision (16):○ 75 Birr guaranteed in 2 weeks - 80 Birr guaranteed in 4 weeks○

Randomly selected decision number: _____

Amount: _____

Payment date: _____

A.2 Confirmation letter given to participants

By participating in the study you made several decisions in the time preference section and the decision that will be used for payment is randomly selected.

Amount: .....
Payment date: .....

On the date indicated in this confirmation letter, we will send the money to your cellphone number using CBE Birr payment. On this date, you will receive a text message from the CBE Birr payment system. The message will contain the amount of money that you will receive. The sender will be XXXX and the sending phone number will be 09XXXXXX. After you have received the text message, you will be able collect the money from the CBE agent at CoBE, any other CBE Birr agent or any CBE branch. When visiting the bank or the CBE Birr agent, please do not forget to bring an identification document (ID) and your cellphone with the CBE Birr text message.

If you have any questions, please contact XXXX at 09XXXXXX.

Experiment ID: .....
Date: .....

Principal investigator name and signature
.....

A.3 Donation instructions

In this section, you will be given an opportunity to donate some or all of your earnings obtained from answering the survey questions to a charity organization named Makedonias Humanitarian Association. Please remember that the show-up fee is not part of the donation and that the maximum donation a participant can give is 100 birr. After we finish the experiment, the total amount donated by all participants will be posted on the board where the advertisement for the experiment was posted.

The Mekedonians Humanitarian Association (MHA) is an indigenous non-governmental, non-profit, and independent organization founded in 2010. The purpose of Mekedonia is to support elderly people and people with disabilities who otherwise have no means of survival by providing them with shelter, clothing, food, and other basic services. The organization is an Ethiopian resident charity under the legal supervision of the Ethiopian Federal Government Charities and Societies Agency. It is headquartered in Addis Ababa, Ethiopia. Currently, MHA is providing shelter and food to 1,500 disabled and destitute elderly people. The beneficiary residents are homeless people picked up from different parts of the country such as Addis Ababa, Hawassa, Debre Zeit, Debre Libanos, and Guder.

Control: "Donate today"

We would like to ask you whether you would like to donate all or some of your earnings from answering the survey question to Mekedonia. You will be asked to answer this question in a minute. If you answer YES, "I'd like to donate today," then you will be asked to specify the amount you would like to donate. The amount specified will be deducted from your earnings and donated to Mekedonia. If you say NO, no donation will be made. Your decisions are final today.

Would you like to donate to Makedonia today?
1. Yes 2. No

If your response is yes, how much would you like to donate to Mekedonia? You can donate any amount between 1 and 100 birr.

..... birr

Treatment 1: "Commit today + Donate later"
We would like to ask you whether you would like to donate all or some of your earnings that you will obtain after answering survey questions in two weeks to Mekedonia. You will be asked to answer this question in a minute. If you answer YES, "I'd like to donate from my earning in two weeks," then you will be asked to specify the amount you would like to donate. The amount specified will be deducted from your earnings in two weeks and donated to Mekedonia. If you say NO, no donation will be made. Your decisions are final today and you will not be asked to make such decisions in the next round (in two weeks).

Would you like to donate to Makedonia from your earnings after two weeks ?
1. Yes 2. No

If you say yes, how much do you like to donate to Makedonia? You can donate any amount between 1 and 100 birr.

..... birr

Treatment 2: "Revise pledge + Donate later "

We would like to ask you whether you would like to donate all or some of your earnings that you will obtain after answering survey questions in two weeks to Mekedonia. You will be asked to answer this question

in a minute. If you answer YES, "I'd like to donate from my earning in two weeks," then you will be asked to specify the amount you would like to donate. In two weeks, you will be reminded of your decision from this week and you will have a chance to either confirm or change your previous decision. Based on your final decision, the amount specified will be deducted from your earnings in two weeks and donated to Mekedonia. If you say NO, no donation will be made. Your decisions in the next round (in two weeks) will be final.

Would you like to donate to Mekedonia from your earnings in two weeks? You will be asked to confirm or change your answer in two weeks.

1. Yes 2. No

If your response is yes, how much do you like to donate to Mekedonia? You can donate any amount between 1 and 100 birr

..... birr

Treatment 2- third round

Before two weeks you were asked whether you would like to donate all or some of your today's earnings, which you obtained from answering this week's survey questions.

Your answer from last round was that you would like to donate ..... X..... birr

This week you will have a chance to either confirm or change your previous decision.

How much would you like to donate to Mekidonia ..... birr

TABLE A.1: *Actual donations and experimentally elicited time preference measures*

Variables	**(1)**	**(2)**	**(3)**
Treatment 1	5.115***	-2.684	6.855**
	(1.850)	(6.758)	(3.021)
Treatment 2	2.234	4.160	0.048
	(1.819)	(5.840)	(2.648)
Age		1.737***	1.776***
		(0.352)	(0.350)
Male		-7.663***	-7.655***
		(2.342)	(2.318)
Department category (Base group=Economics)			
Accounting		0.784	1.154
		(2.206)	(2.155)
Public Administration		-1.814	-1.975
		(1.998)	(2.014)
Management		-1.920	-1.613
		(2.227)	(2.157)
Year at the University (Base group=3rd year students)			
2nd year student		1.992	1.866
		(1.494)	(1.487)
Religion of participants (Base group=Orthodox Christian)			
Muslim		-3.682**	-3.390*
		(1.747)	(1.802)
Protestant		-3.380	-3.159
		(2.078)	(2.120)
Other religion		-10.879***	-10.564***
		(2.720)	(2.953)
Trust in charity organizations		1.299**	1.222*
		(0.624)	(0.629)
Monthly income (in birr)		0.008***	0.008***
		(0.002)	(0.002)
Risk attitude		0.117	0.116
		(0.276)	(0.279)
Have visited Makedonia before		1.525	1.668
		(2.224)	(2.265)
Have donated to Makedonia before		3.077**	2.953**
		(1.433)	(1.438)
Dummy for multiple switch		-4.092	-4.356
		(2.899)	(2.975)
Discount factor		-11.862*	-5.121
		(7.054)	(4.267)
Treatment 1#Discount factor		13.117	
		(9.537)	
Treatment 2#Discount factor		10.223	
		(8.457)	

Continued on next page

Table A.1 – *Continued from previous page*

Variables	**(1)**	**(2)**	**(3)**
Time preference (Base group=Time consistent)			
Present-biased			-1.946
			(2.554)
Future-biased			-2.078
			(2.304)
Present-biased#Treatment 1			-3.463
			(4.848)
Present-biased#Treatment 2			3.366
			(4.631)
Future-biased#Treatment 1			-1.579
			(3.914)
Future-biased#Treatment 2			5.475
			(3.749)
Constant	13.950***	-18.574**	-22.561***
	(1.060)	(9.000)	(8.238)
Observations	435	435	435
R-squared	0.017	0.165	0.169

Note: In all columns, we present coefficient of OLS regressions with robust standard errors. The dependent variable in all columns is actual donations in birr, and participants who switched multiple times in the time preference experiment are included in the analysis. *** p<0.01, ** p<0.05, * p<0.1

TABLE A.2: *Marginal effect of actual donation and experimentally elicited time preference measures*

Variables	**(1)**	**(2)**	**(3)**
Treatment 1	5.115***	5.659***	5.718***
	(1.850)	(1.855)	(1.846)
Treatment 2	2.234	2.342	2.421
	(1.819)	(1.740)	(1.729)
Dummy for multiple switch		-4.092	-4.356
		(2.899)	(2.975)
Discount factor		-4.505	-5.121
		(3.990)	(4.267)
Present-biased			-1.992
			(2.069)
Future-biased			-0.867
			(1.566)
Observations	435	435	435
R-squared	0.017	0.165	0.169
Controls	NO	YES	YES

Note: In all columns, we present marginal effect coefficient from OLS regressions with robust standard errors. The dependent variable in all columns is actual donation in birr. Covariates include age, gender, department, year at the university, religion, monthly income, risk attitude, trust in charity organizations, and previous visits and past donations to Mekedonia. Participants who switched multiple times in the time preference experiment are included in the analysis. *** p<0.01, ** p<0.05, * p<0.1

TABLE A.3: *Actual donations and experimentally elicited time preference measures*

Variables	**(1)**	**(2)**	**(3)**
Treatment 1	5.022**	-8.120	6.459**
	(1.947)	(8.829)	(3.182)
Treatment 2	2.366	-8.247	-0.494
	(1.928)	(7.743)	(2.795)
Discount factor		-17.695*	-6.589
		(9.238)	(4.619)
Present-biased			-3.039
			(2.750)
Future-biased			-3.197
			(2.526)
Present-biased#Treatment 1			-5.120
			(5.120)
Present-biased#Treatment 2			4.881
			(5.124)
Future-biased#Treatment 1			-0.258
			(4.086)
Future-biased#Treatment 2			6.336
			(3.979)
Treatment 1#Discount factor		20.546*	
		(12.262)	
Treatment 2# Discount factor		16.007	
		(10.914)	
Constant	14.048***	-26.008*	-31.681**
	(1.140)	(15.755)	(15.475)
Observations	401	401	401
R-squared	0.016	0.168	0.173
Controls	No	YES	YES

Note: In all columns, we present coefficient of OLS regressions with robust standard errors. The dependent variable in all columns is actual donations in birr. Covariates include age, gender, department, year at the university, religion, monthly income, risk attitude, trust in charity organizations, and past visits and donations to Mekedonia. Participants who switched multiple times in the time preference experiment are excluded from the analysis. *** p<0.01, ** p<0.05, * p<0.1

TABLE A.4: *Effect of others pledges or donations on own donation*

Variables	**(1)**	**(2)**	**(3)**
Mean donation by others same class and year	-0.029		
	(0.389)		
Mean donation by others same class, year and treatment two		0.117	
		(0.256)	
Mean donation by others same class, year and session			0.097
			(0.238)
Constant	16.699**	13.746**	14.161***
	(7.040)	(5.323)	(5.046)
Observations	136	136	136
R-squared	0.000	0.001	0.003

Note: In all columns, we used OLS regression excluding donor characteristics, and robust standard errors presented are in parentheses. The analysis only includes participants in treatment two. The dependent variable in all columns is actual donation in birr. In column (1), we use mean donation by others in the same class and year regardless of treatment. Column (2) uses the mean donation by others computed for those in treatment two, year and department. Column (3) uses the mean donation by others computed for those in the same session in the experiment, year and department. *** p<0.01, ** p<0.05, * p<0.1

TABLE A.5: *Association between risk attitude and actual donations*

Variables	**(1)**	**(2)**	**(3)**
Treatment 1	5.115***	6.028	6.409
	(1.850)	(4.608)	(4.772)
Treatment 2	2.234	0.223	-2.310
	(1.819)	(3.980)	(4.201)
Risk attitude		-0.016	-0.046
		(0.563)	(0.567)
Treatment 1#Risk attitude		-0.064	0.043
		(0.826)	(0.832)
Treatment 2#Risk attitude		0.408	0.421
		(0.638)	(0.650)
Present-biased			-1.444
			(2.530)
Future-biased			-2.705
			(2.350)
Present-biased#Treatment 1			-2.979
			(4.954)
Present-biased#Treatment 2			3.642
			(4.648)
Future-biased#Treatment 1			-1.306
			(3.905)
Future-biased#Treatment 2			5.478
			(3.779)
Dummy for multiple switch		-2.556	-3.117
		(2.465)	(2.680)
Constant	13.950***	-27.668***	-25.740***
	(1.060)	(9.422)	(9.200)
Observations	435	435	435
R-squared	0.017	0.157	0.166
Controls	NO	YES	YES

Note: In all columns, we present coefficient from OLS regressions with robust standard errors. The dependent variable in all columns is actual donation in birr. Column (2) includes the interaction term between risk attitude and the treatment while column (3) contains the interaction between both risk attitude and hyperbolic time preference and the treatment. Covariates include age, gender, department, year at the university, religion, monthly income, risk attitude, trust in charity organizations, and previous visits and past donations to Mekedonia. Participants that switched multiple times in the time preference experiment are included in the analysis. *** p<0.01, ** p<0.05, * p<0.1

TABLE A.6: *Actual donations and monetary withdrawal behavior in the field*

Variables	**(1)**	**(2)**	**(3)**
Treatment 1	7.763***	5.311***	9.159
	(2.625)	(2.011)	(7.404)
Treatment 2	6.965***	3.523*	-5.283
	(2.467)	(1.876)	(5.432)
	(5.169)	(21.745)	(7.479)
No. of days before the first withdrawal (Base group=Same day)			
One day	2.530		
	(3.339)		
Two days	3.656		
	(2.970)		
Three or more days	4.279		
	(4.166)		
One day#Treatment 1	-5.211		
	(4.971)		
One day#Treatment 2	-8.807**		
	(4.276)		
Two day#Treatment 1	-8.172		
	(5.177)		
Two day#Treatment 2	-13.052**		
	(5.101)		
Three days#Treatment 1	-2.226		
	(5.858)		
Three days#Treatment 2	-6.074		
	(6.162)		
No. of days before withdrawal		0.232	
		(0.272)	
Treatment 1#No. of days before withdrawal		0.228	
		(0.145)	
Treatment 2#No. of days before withdrawal		-0.161*	
		(0.085)	
Proportion of money withdrawn			-8.801
			(8.318)
Treatment 1#Proportion of money withdrawn			-3.424
			(7.976)
Treatment 2#Proportion of money withdrawn			9.429
			(6.114)
Constant	-38.941**	-35.280**	-30.854*
	(16.120)	(16.407)	(16.845)
Observations	401	401	401
R-squared	0.177	0.179	0.170
Controls	No	YES	YES

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Table A.6 – *Continued from previous page*

Variables	**(1)**	**(2)**	**(3)**

Note: In all columns, we present coefficient of OLS regressions with robust standard errors. The dependent variable in all columns is actual donations in birr. Covariates include age, gender, department, year at the university, religion, monthly income, risk attitude, trust in charity organizations, previous visits and past donations to Mekedonia, amount sent to participants, dummy for withdrawing money, and dummy for buying mobile card with the money sent. Participants who switched multiple times in the time preference experiment are excluded from the analysis. *** p<0.01, ** p<0.05, * p<0.1

TABLE A.7: *Marginal effects for actual donations and amount earned in the time preference experiment*

Variables	**(1)**	**(2)**	**(3)**
Treatment 1	5.115***	5.710***	5.779***
	(1.850)	(1.836)	(1.826)
Treatment 2	2.234	2.419	2.511
	(1.819)	(1.715)	(1.703)
Earnings from time preference exp.		-0.035	-0.041
		(0.072)	(0.076)
Discount factor		-3.471	-3.867
		(3.852)	(4.018)
Present-biased			-2.018
			(2.080)
Future-biased			-0.936
			(1.573)
Observations	435	435	435
Controls	NO	YES	YES

Note: The dependent variable in all columns is actual donation in birr. Covariates include age, gender, department, year at the university, religion, monthly income, risk attitude, dummy for multiple switching, trust in charity organizations, and previous visits and past donations to Mekedonia. In all columns, we used OLS regressions with robust standard errors. Participants who switched multiple times in the time preference experiment are included in the analysis. *** p<0.01, ** p<0.05, * p<0.1

TABLE A.8: *Average donation by earnings in the time preference experiment*

Amount earned in time preference experiment	Number of Observation	Average donations in birr
10	2	60
20	5	14
30	8	9.4
40	16	12.2
50	32	14.7
60	44	18.6
70	63	16.8
75	44	14.6
80	221	16.4

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Measuring Trust in Institutions*

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Abstract

In empirical studies, survey questions are typically used to measure trust; trust games are also used to measure interpersonal trust. In this paper, we measure trust in different institutions by using both trust games and survey questions. We find that generalized trust is only weakly correlated with trust in specific institutions, when elicited both by using a trust game and by using survey questions. However, the correlation between trust in a specific institution elicited through a trust game and stated trust for the same institution is stronger and statistically significant. Thus, our findings suggest that generalized trust is not an appropriate measure of institutional trust and that more specific institutional trust measures should be used.

JEL Codes: C90, D01, D02, O43.

Keywords: Experiment, institutional trust, generalized trust.

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"Trust is an important lubricant of a social system. It is extremely efficient; it saves a lot of trouble to have a fair degree of reliance on other people's word. Unfortunately, this is not a commodity which can be bought very easily. If you have to buy it, you already have some doubts about what you have bought."

— Arrow (1974)

1 Introduction

Trust is a key component in economic activities and is seen by many economists as an important factor for economic growth (Beugelsdijk et al., 2004; Fehr, 2009; Knack and Keefer, 1997; La Porta et al., 1997; Zak and Knack, 2001) and institutional development (La Porta et al., 1999; Putnam, 1995). Investigations of how trust affects different economic outcomes, such as economic growth, have traditionally been based on responses to survey questions such as the World Values Survey trust question: "Generally speaking, would you say that most people can be trusted or that you can't be too careful in dealing with people?" Trust in institutions is an important factor in explaining why trust has a positive impact on economic growth, typically explained by reduced transaction costs (Fukuyama, 1995). Trust can act as a substitute for reputation in facilitating cooperation and coordination when there are transaction costs (Algan and Cahuc, 2013). Thus, it is important to understand how people trust institutions per se, because this is a crucial factor in understanding the role of institutional trust in economic prosperity.

Trust is a complex concept, and one might question the possibility of capturing such a concept by only using one or two measures. Institutional trust is related to the concept of linking social capital and defines relationships with others who are in a different power position, such as those working for institutions.[1] This is different from bonding and

[1]While trust and social capital are usually used interchangeably in the economics literature, distinctions exist between the two, as the former is a subset of the latter (Knack and Keefer, 1997; Loury, 1977; Putnam, 1995).

bridging trust, which relate to relationships with other people similar to oneself and more distant people such as those of a different age or social class, respectively (Szreter and Woolcock, 2004). It should be noted that trust experiments and most survey questions on trust relate to either bonding or bridging, whereas linking trust has not been as extensively studied. However, if we would like to understand and quantify the role of trust in institutions, we do need to be able to measure it in a rather simple way.

In this paper, we measure institutional trust with a traditional survey module and with a novel institutional trust experiment. Our paper relates to a small but growing literature on measures of trust in institutions. A related strand of literature has investigated generalized trust, where stated trust and behavior in trust games have been compared (see e.g. Ashraf et al., 2006; Bellemare and Kröger, 2007; Fehr et al., 2003; Holm and Danielson, 2005; Johansson-Stenman et al., 2013; Johnson and Mislin, 2012). We complement the literature on individual trust by investigating trust in institutions. However, in the case of trust in institutions it is not obvious how behavior in a trust game, with a focus on specific individuals, relates to stated measures about trust in institutions per se. For this reason, we measure trust in a couple of different ways. First, we conduct an institutional trust game between entrepreneurs and employees at different government institutions, in addition to standard trust game with other people as trustees. Second, we elicit trust towards employees at different institutions and trust in the institutions in general using survey questions together with generalized trust questions. We investigate if there is convergent validity between the different measures, i.e., to what extent the measures are correlated with each other. In particular, we will compare the different stated measures of trust with the behavior in the trust experiment.

There is no single definition of institutional trust.[2] Our emphasis is on how individuals' trust might be institution-specific, which means that we will take a micro perspective. To what extent an individual trusts a par-

[2]For a discussion on institutional trust, see (Coleman, 1990; Dasgupta, 1988; Mishler and Rose, 2001)

ticular institution will depend on preferences and experiences, especially one's personal experiences with the institution. These experiences can be general, but also can be based very much on specific interactions. One definition of trust put forward in the domain of interpersonal trust defines trust as "a particular level of the subjective probability with which an agent assesses that another agent or group of agents will perform a particular action, both before he can monitor such action ... and in a context in which it affects his own action" (Gambetta, 2000, P 217). In other words, when we say we trust someone, we implicitly mean that the probability that he will perform an action that is beneficial, or at least not detrimental, to us is high enough for us to consider engaging in some form of cooperation with him (Gambetta, 2000).[3] While this definition is given in an interpersonal relationship setup, most of the elements could be extended to trust in institutions. Put differently, trust in institutions is related to trust in the individuals at the institution, as well as to trust in the institution itself.

Trust has primarily been elicited using two different approaches: survey questions and trust experiments.[4] However, measures of institutional trust have been based solely on stated measures of trust.[5] In surveys, such as the World Values Survey and Gallup World Poll, confidence rather than trust in different government institutions is measured through questions such as: "Could you tell me how much confidence you have in different institutions listed below: quite a lot of confidence, not very much confidence or none at all?" In this study, we specifically ask how much entrepreneurs trust institutions instead of using the word confidence, which is a closely related concept. More importantly, unlike the usual practice when measuring stated trust in institutions, we ask not only about trust in the institutions, but also about trust in the employ-

[3]For a discussion on how risk affects trust in trust experiments, see Eckel and Wilson (2004); Houser et al. (2010); Schechter (2007).

[4]For a general discussion on using survey questions and experiments, see Falk and Heckman (2009).

[5]There are a few execptions like Friebel et al. (2016) who look at what type of individual that self-select into a public job, in their case the police, and Murtin et al. (2018) that use an implicit association test to measure trust in government as well as a standard stated trust question.

ees of the institutions. When individuals are asked to state how much they trust a given institution, it is not clear whether they think of the institution itself, the employees working at the institution, or both. Furthermore, as we have discussed, trust in an institution depends on the trust in the individuals at the institution. At the same time, by focusing on individuals working at the institution and not the institution per se, we might measure other aspects of trust that we do not intend to measure. The most obvious example is that with a focus on the individuals we might be capturing aspects such as a trust that corrupt individuals will keep their promises, etc. It is therefore of interest to compare these two measures. The second reason why we want to measure trust in individuals at the institution is that we want to compare that with behavior in an institutional trust game. In both cases, what we mean by trust, therefore, is the institutions or the employees of the institution follow the law in their service deliveries to the public and do not engage in practices that go against the law.

Another strand of trust research has focused on measuring individual trust using an experimental approach. Berg et al. (1995) invented the trust game (sometimes referred to as the investment game), which is an experiment that allows causal inferences of trust and trustworthiness. The game has since been extensively applied (for an overview, see Johnson and Mislin, 2011). Typically, both the trustor and trustee are endowed with the same amount of money at the beginning to rule out the possibility that transfer from trustor to trustee might be related to social preferences such as inequality aversion or altruism. The trustor can transfer money to a trustee and any amount sent is tripled before it is handed over to the trustee. Then, the trustee can return any amount received to the trustor. The game captures the key aspect of trust: the more an individual trusts another, the more money he or she will send, so the amount sent is a measure of trust. The amount returned is interpreted as trustworthiness. If more than one-third of the amount received, which is the tripled amount of what the trustor sent is returned by the trustee, then it paid off for the trustor to trust. A meta-study by Johnson and Mislin (2011) shows that, on average, trustors send 50% of the

endowment and trustees return 37% of the amount received. Thus, on average, it pays off for a trustor to trust, but trustees keep the larger share of the surplus generated by trusting. However, these studies have focused on interpersonal trust. Few studies have investigated trust in institutions. For example, Friebel et al. (2016) find in a trust game that that German university students trust police applicants more than they trust high school students. In a cross-country study, Murtin et al. (2018) find that stated trust in others explains trust in government, while trust elicited in a trust game does not.

In this paper, we apply a trust game with employees at a specific institution as trustees. Unlike what is usually done in measuring trust using experiments, we make the identity of the trustee more explicit in our study by emphasizing to what specific institution the trustee belongs. To measure institutional trust, we needed a set of different institutions and a population that has experience with the institutions and a belief about the degree of trust. Because of this, we conducted the institutional trust experiment with entrepreneurs who own and manage micro-, small-, and medium-sized enterprises in Addis Ababa, Ethiopia. Ethiopia is currently experiencing rapid economic growth in which entrepreneurs are important actors. Micro-, small-, and medium-sized enterprises are seen as an engine of economic growth for developing countries (Daniels, 1999; Tybout, 2000). We investigated their trust in four different institutions with which they interact frequently. A high level of trust in government creates smooth implementation of economic policies, as entrepreneurs will not be suspicious of the government and its intentions (Exadaktylos and Zahariadis, 2012). Moreover, trusting entrepreneurs are more likely to deliver on their economic responsibilities, such as tax compliance and environmental protection (Kogler et al., 2013; Scholz and Lubell, 1998).

The rest of the paper is organized as follows. In Section 2, we describe how we measure trust, the experiment and survey questions, our sample, and the procedure we followed. Section 3 presents both descriptive and econometric analysis of the results. Finally, Section 4 concludes our paper.

2 Measurement of Institutional Trust

The trust experiment and the survey questions on trust were done as part of a survey study on entrepreneurs in Addis Ababa, Ethiopia. The trust experiment was done in the last section and the survey questions on institutional trust were done in the middle of the survey to keep them apart.

2.1 The Institutional Trust Experiment

The institutional trust experiment followed the same basic design as the standard trust game developed by Berg et al. (1995). Both trustors and trustees each received an endowment of 100 birr (US $4.45)[6] which corresponds to roughly 1.5 times a daily laborer's wage in Addis Ababa during the survey period. By giving the same endowment to both trustor and trustee eliminates several other motives for sending money to the trustee, such as inequality aversion and altruism. The trustors had to decide how much to keep and how much to send to a trustee. The amount sent to a trustee was tripled and then the trustee decided how much to keep and how much to return to the trustor.

There were six different trustees and subjects were asked how much they would send to each of the six trustees, presented in random order. However, only one of the six decisions was played for real payment. This was determined by a random draw after all six decisions had been made. The randomly selected trustee was then informed about the trust experiment and had to decide how much of the amount that had been sent and tripled to return to the trustor and how much to keep. This part of the design builds on the experiment of Falk and Zehnder (2013), in which each trustor decided how much to send to 12 different trustees, out of whom only one was finally payoff relevant. In the trust experiment, we included six different types of trustees: (i) a randomly selected resident of Addis Ababa; (ii) a randomly selected owner of a micro-, small-, and

[6] At the time of the experiment (April 2017) the exchagne was US $1 to 22.8 Birr.

medium-sized enterprise in the district (woreda[7]); (iii) a randomly selected employee at the district's (woreda's) micro and small enterprises development agency; (iv) a randomly selected employee at the district (woreda) administration; (v) a randomly selected employee at the district (woreda) tax authority; and (vi) a randomly selected employee at a sub-regional branch of the electric utility. The presented order was randomized for each subject. The first category, a randomly selected resident of Addis Ababa, can be used as a benchmark to previous trust games.

For each decision, the trustor was given one blue and one green envelope with the same number printed on each envelope. The blue envelope contained 100 birr. The green envelope was empty and had the type of trustee printed on it. The trustor was told to put the amount of money he or she would like to send to the specific trustee in the green envelope. Once the trustor had made a decision, he or she was asked to seal the envelope (even if he or she had decided to send nothing) and give it to the enumerator. The enumerator turned his or her back during the decision process so that the trustor could make a decision in secrecy. This procedure was repeated six times. To reduce the influence of order effects, we randomized the order in which the trustees were presented. Once the trustor was done with all six decisions, the enumerator rolled a six-sided die to determine which of the six trustees would receive the payout. The blue envelope that corresponded to the randomly drawn number was given directly to the trustor, while the green envelope was kept for transfer to the trustee. The enumerator brought back the five pairs of envelopes that had not been selected to be payout-relevant and one single envelope from the payout-relevant decision that contained the amount to be sent to the trustee by the principal researchers. The principal researchers then opened the envelopes, recorded the amounts sent, and put the tripled amount in the payout-relevant decision in a new envelope given to the randomly selected trustee.

[7] A woreda is an administrative government unit in the capital Addis Ababa. The city is divided into 10 sub-cities.

In the next step, depending on which of the six trustees had been randomly selected, a trustee matching the criteria was randomly selected and then approached and informed about the experiment. After the instructions had been read, the trustee was given a green envelope containing the tripled amount and an empty blue envelope. The enumerator asked the trustee to decide how much money he or she would like to send back to the trustor and how much to keep. The enumerator then turned his or her back so that the trustee could make the decision in private. The trustee was instructed to put the amount of money he or she would like to send back in the empty blue envelope. Once the trustee was done, he or she sealed the blue envelope and gave it to the enumerator, keeping the green one. The envelope was brought back to the principal researchers who then opened the envelope and recorded the amounts sent before it was given to the trustor.

2.2 Stated Institutional Trust

We separately elicited the trust that entrepreneurs have toward the institutions and toward the employees working in these institutions. The question to measure trust for an institution was: "Please tell me on a scale of 0 to 10 how much you personally trust each of the institutions listed below, where 0 means you do not trust the institution at all and 10 means you have complete trust." The question to measure trust for employees at the institutions was: "Please tell me on a scale of 0 to 10 how much you personally trust an employee/individual of the institutions listed below, where 0 means you do not trust the employee/individual at all and 10 means you have complete trust."

2.3 Description of Sample

We sampled the trustors from all micro-, small-, and medium-sized enterprises in Addis Ababa in two stages. First, we randomly chose 260 firms from a list of more than 20,000 registered micro-, small-, and medium-sized enterprises obtained from the Addis Ababa Trade Bureau and the

Central Statistical Agency. Then, we chose owner-managers of these enterprises to be the subjects in our study, because they make the important decisions and, hence, have a direct working relationship with the various government institutions. If an enterprise had more than one owner, we selected the owner who was most involved in the day-to-day operations of the enterprise. From this selected sample, only two entrepreneurs refused to participate in the trust experiment due to their belief that it went against their religious beliefs.[8] In a few cases, the respondents were general managers or spouses of the owners. [9] Descriptive statistics of the trustors are presented in Table 1.

TABLE 1: *Descriptive Statistics of Trustors*

Variable	*N*	Mean	Std. dev.	Min.	Max.
Age (in years)	257	38.34	10.20	22	76
At least a college diploma	258	0.29	0.45	0	1
Male	255	0.78	0.42	0	1
Married	258	0.71	0.45	0	1
Christian Orthodox	251	0.76	0.42	0	1
Muslim	251	0.10	0.30	0	1
Protestant	251	0.14	0.34	0	1
Preference for risk taking (between 0 and 10, where 10 is completely risk taking)	258	4.63	3.31	0	10
Business experience (in years)	253	6.88	6.28	0	43
Total number of employees	258	10.05	11.95	1	86
Industry zone location	258	0.32	0.47	0	1
Monthly revenue (in 1,000 birr)	255	45.59	113.99	0	1,000
More than one owner	258	0.45	0.50	0	1
Amhara (=1 if ethnically Amhara)	248	0.40	0.49	0	1
Oromo (=1 if ethnically Oromo)	248	0.16	0.36	0	1
Guraghe (=1 if ethnically Guraghe)	248	0.17	0.37	0	1
Tigray (=1 if from Tigray)	248	0.15	0.35	0	1
Other ethnic groups	248	0.12	0.29	0	1

[8]The two respondents who refused to participate were Muslims who said that the experiment resembled gambling.

[9]Such cases account for about 3% of our sample (nine enterprises) and the results are robust without these observations.

About one-third of the trustors have attained at least a college diploma and 78% of them are men. We also asked trustors regarding their risk preferences using a stated risk question. The stated risk preference question was asked on a scale from 0 to 10, where 0 represents completely risk averse and 10 represents completely risk taking. Using this measure, an average trustor in our sample considers himself or herself as risk neutral. The average experience as a business owner is almost seven years. In terms of business locations, about a third of the micro-, small-, and medium-sized enterprises that trustors own or represent are located in industry zones or clusters. These clusters are government-provided production areas, usually with very low rental rates. An average micro-, small-, or medium-sized enterprise owned by a trustor reports about 45,000 birr of monthly revenue.

The trustees in our experiment were from six different groups. The first two categories included a randomly selected resident of Addis Ababa and an entrepreneur operating in the trustor's district. The other four categories were government institutions that implement rules at the district level and provide various services that are sometimes important for the establishment, survival, and growth of firms. The entrepreneurship development agency is mainly responsible for nurturing entrepreneurship. This agency provides technical support, facilitates financial access through loans, establishes market linkages through business fairs, and offers business training. The district (woreda) administration is the lowest level of the executive branch of the Ethiopian government in Addis Ababa. It issues and renews licenses, executes the government's labor and environmental regulations, and provides local-level public infrastructure. The third government institution included as a trustee was the tax authority, which is mainly responsible for introduction and enforcement of tax regulations at the lowest administrative level. It provides tax identification numbers, requires businesses to report monthly income statements, collects various taxes, and takes legal measures against tax evaders. The fourth institution is the electric utility, a public utility that is solely responsible for the generation and distribution of electricity service across the whole country, making it a natural monopoly. The utility

also collects electricity fees and provides technical support during power outages. These four government institutions together provide the overwhelming majority of services that micro-, small-, and medium-sized enterprises operating in Addis Ababa require for their very existence. Entrepreneurs make frequent visits to the offices of these institutions, giving them the opportunity to interact with the employees of the institutions, starting from the time their firms were established and continuing during their operation.

The micro-, small-, and medium-sized enterprises owned and operated by trustors in our experiment are located in different parts of Addis Ababa and are served by different branches of the institutions. This is mainly because of the decentralized structure of the government offices in the city. The city administration is divided into 10 sub-cities, which are further decentralized into 116 districts (woredas). Three of the institutions we consider in our experiment – the tax authority, entrepreneurship development agency, and district administration – have their lowest administrative branches at the district level and each has about 85 different branches. Unlike the other three institutions, the electric utility is organized into four regional branches.[10] Even though there are generally similar pay scales for similar positions within each branch of a given institution (as they are set to be equal by the government), there might be heterogeneity in how employees perform their work.

We collected a range of observable characteristics for each branch of the institutions from the human resources departments. Since the owners of the micro-, small-, and medium-sized enterprises are in frequent contact with all these institutions, they should have perceptions about the individuals working in these institutions. In addition, other characteristics of employees, such as average earnings and educational qualifications, are common knowledge among the general population, as this information is publicly available. Table 2 presents the average socioeconomic characteristics of employees of the institutions.

[10]The four regional branches are the North, East, South, and West Addis Ababa offices.

TABLE 2: *Descriptive Statistics of Employees of the Institutions*

Institution	Average monthly salary(in birr)	Average age(in years)	Proportion of men	Proportion of employees with at least a college diploma
Entrepreneurship development agency	4.926	30.20	0.75	0.83
	(1,199)	(2.09)	(0.19)	(0.17)
Tax authority	5.998	34.48	0.52	0.47
	(1,298)	(2.93)	(0.25)	(0.21)
District	2.861	32.33	0.49	0.52
	(704)	(2.45)	(0.09)	(0.09)
Electric utility	3.973	38.94	0.74	0.55
	(131)	(2.09)	(0.02)	(0.07)

Among the four institutions, the entrepreneurship development agency has the youngest employees, but it has the largest proportion of male employees and the highest number of employees having at least a college diploma. The tax authority has the highest average salary, while it also has the lowest share of workers who have at least a college diploma. Compared with the other three institutions, the electric utility employees have the highest average age.

2.4 Procedure

The trust experiment was part of a larger firm survey conducted in collaboration with the Ethiopian Development Research Institute (EDRI). As the institute conducts a wide range of surveys among both households and firms in the city, it was known to most of the participants as a neutral research institute. Mo reover, to assure participants that the survey and the experiment were being conducted for the sole purpose of research, enumerators presented an official letter issued by EDRI addressed to the respective enterprises explaining this and asking for their participation. We believe the political neutrality of the institute, along with the assurances that the participants' responses would be treated with the utmost confidentiality ensured good quality responses. Enumerators were given the physical addresses of the micro-, small-, and

medium-sized enterprises randomly selected for participation. Upon arrival at the participants' places of business, enumerators were instructed to first introduce themselves and show the official letter from EDRI asking whether the participant would like to participate in a survey. If the answer was yes, the survey was conducted either immediately or by appointment (in situations where the owner or manager of the enterprise was not present during the first visit).[11]

In the last part of the survey, the trust experiment was conducted. An enumerator read aloud the instructions, which explained that both trustor and trustee would have the same initial endowment, the different stages of the experiment, and how payout would be determined. We also incorporated three different examples elaborating the outcomes of different decisions. To reduce any influence that providing examples might have, two of the examples had either a small or a large amount being sent, while the third presented a situation where half of the endowment was sent. As our subjects were entrepreneurs and, hence, relatively literate individuals, it was easy for them to understand the experiment, as we already knew from our pilot studies. However, to avoid any possible misunderstanding, we kept this format. We informed trustors that they would be paid within four weeks.

The trustees were selected in different ways depending on the group to which they belonged. For the randomly selected resident of Addis Ababa, we drew from a sample list of about 35,000 households obtained from EDRI,[12] taking into account the population densities of the 10 sub-cities of Addis Ababa. From each of the 10 sub-cities, we randomly chose one district. Based on the population densities, we randomly chose three individuals from eight of the districts and two individuals from the remaining two districts. For fellow entrepreneurs operating in the trustor's district, we randomly selected them from a list of registered micro-, small-, and medium-sized enterprises operating in the same district as the trustor. To choose trustees who were employees of the four

[11] In case the owners or managers of some enterprises could not be reached, we had also prepared a replacement list in advance.

[12] We used this list because we were unable to obtain an official registry.

government institutions, we first obtained complete lists of employees of each district branch. From these lists, one person was randomly selected if that institution had been drawn in the first stage.[13] For each randomly selected employee, we provided enumerators, with one reserve employee as a replacement in case the employee was on leave or away for a longer period.[14]

Trustees were then approached and informed about the trust experiment in a similar manner as the trustors, including all details. The instructions were also read aloud to the trustees and they were then informed about what happened during the first stage of the experiment. We also presented them with similar examples as we did with the trustors. Once the instructions were read, trustees were each given two envelopes, a green envelope containing the tripled amount and a blue envelope that was empty. After the trustees had made their decisions, the enumerators brought the blue envelopes back to the principal researchers, who counted and recorded the amounts sent back by the trustees. The trustors were then contacted again and received the money the trustees had sent.

3 Results

We first present the results from the trust experiment, where we present the amount sent to each trustee category as a measure of trust. Then, we present the findings from the stated trust questions, where we measure the level of trust toward the different trustee categories separated on trust towards the institution in general and to the employees of the institution, using the stated trust questions. Finally, we compare experimental results and stated trust, including generalized trust.

[13] However, it is possible that more than one employee of a given local branch of the institution would be selected as a trustee if there had been more than one draw of trustors served by the given branch in the first stage.

[14] In practice, this happened in only a few instances, about 2% of the cases.

3.1 The Institutional Trust Experiment

In total, we had 258 trustors deciding how much of their endowment to send to the trustee. Descriptive statistics of the amounts sent are presented in Table 3.

TABLE 3: *Amount Sent by Trustors to the Different Trustee Categories (N = 258)*

Trustee category	**Mean amount sent (in birr)**	**Standard deviation**	**Proportion of trustors sending zero**	**Mean amount sent (in birr) conditional on sending nonzero**
A resident of Addis Ababa	45.74	28.35	0.078	49.58
Entrepreneur in the same district	45.66	28.79	0.105	51.00
Entrepreneurship dev. agency employee	43.53	30.70	0.132	50.13
District administration employee	35.54	28.27	0.178	43.25
Tax authority employee	34.57	28.38	0.213	43.94
Electric utility employee	32.05	27.55	0.225	41.35

There are clear differences when it comes to the amount sent to the different trustee categories. Only 9% of our sample sent the same amount to all the trustee categories. The trustors sent considerably more to a random resident of the city and an entrepreneur than to any of the employees of the four institutions. Among the institutions, the highest amount was sent to employees at the entrepreneurship development agency. This is perhaps not surprising, since that agency's main task is to support entrepreneurs. The amount sent to employees at the electric utility was about 30% lower than the amount sent to a random resident of the city.

In a more detailed analysis of the amount sent, we look at the proportion of trustors who sent zero and the amount sent conditionally on sending a nonzero amount. The proportion of trustors sending zero to the trustee categories ranged from 0.078 for a random resident to 0.225 for an employee of the electric utility, while the conditional amount sent ranged from 51% for an entrepreneur in the same district to 41.35% for an electric utility employee. Interestingly, a district administration

employee, tax authority employee, and electric utility employee are less likely than the other three trustee categories to receive any amount; and if they receive anything, they receive less than the other categories.

In Table 4, we provide a more detailed comparison of the amounts sent to the six different categories and a statistical test of the differences.

TABLE 4: *Differences in Amounts Sent in birr among Trustee Categories (p-values of Wilcoxon signed-rank test in parentheses) (N = 258)*

	Entrepreneur in the same district	**Entrepreneurship dev. Agency**	**District (woreda)**	**Tax authority**	**Electric utility**
A resident of Addis Ababa	0.08 (0.707)	2.21 (0.471)	10.20*** (<0.001)	11.17*** (<0.001)	13.69*** (<0.001)
Entrepreneur in the same district		2.13 (0.247)	10.12*** (<0.001)	11.09*** (<0.001)	13.61*** (<0.001)
Entrepreneurship dev. agency			7.99*** (<0.001)	8.96*** (<0.001)	11.48*** (<0.001)
District (woreda)				0.97 (0.727)	3.49 (0.135)
Tax authority					2.52** (0.035)

Note. *, **, *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 4 shows the differences in amount sent among different trustee categories. For example, 0.08 in the top right corner of the table indicates that a trustor sends 0.08 more to a resident of Addis Ababa than to an entrepreneur in the same district. Pairwise comparisons of amounts sent to different categories show that the difference in amounts sent are statistically significant for most of the combinations (10 out of 15 cases). The largest difference is when we compare the amounts sent to our benchmark groups (a resident of Addis Ababa or entrepreneur in the same district) and the three government institutions. The differences are also statistically significant when we compare the amount sent for the entrepreneurship development agency with the three other institutions: the amount of money sent to the development agency is consistently higher. Among the remaining three institutions, the amount sent to an employee of the tax authority is statistically significantly higher than

the amount sent to an employee at the electric utility. Overall, what we find is that micro-, small-, and medium-sized enterprise owners appear to have less trust in government institutions.

Next, we investigate to what extent observables correlate with the amounts sent to the four different institutions and the regression results are shown in Table 5. We pool the observations for the four different institutions and include several characteristics describing the institutions and the trustor. In the first model, we only include dummy variables for the different institutions (with the entrepreneurship development agency as the base group). In the second model, we include institutional and trustor characteristics.

TABLE 5: *Regression Analysis of Stated Trust in Institutions in General*

Variables	**(1)**	**(2)**
Institutions(base group = Entrepreneurship development agency)		
Tax authority	–9.131***	-10.420*
	(4.24)	(1.85)
Electricity utility	–12.488***	-12.110***
	(6.27)	(3.14)
District administration	–8.581***	-2.162
	(4.47)	(0.52)
Institutional characteristics		
Average salary (in 1000 birr)		2.125
		(1.60)
Average age		0.251
		(0.66)
Proportion of males		7.023
		(0.93)
Proportion of employees with at least a college diploma		2.651
		(0.29)
Trustor characteristics		
Age (in years)		0.307*
		(1.85)
At least a college diploma		0.469
		(0.14)
Male		-5.103
		(1.45)
Married		4.679
		(1.46)
Risk preference		0.835*
		(1.90)
Business experience		-0.132

Continued on next page

Table 5 – *Continued from previous page*

Variables	**(1)**	**(2)**
		(0.51)
Total number of employees		0.117
		(0.74)
Industry zone location		7.798**
		(2.31)
Monthly revenue (in 1,000 birr)		-0.014
		(0.95)
More than one owner		-7.426**
		(2.22)
Religion (base group = Christian Orthodox)		
Muslim		3.003
		(0.52)
Protestant		5.058
		(1.14)
Ethnicity (base group = Tigray)		
Amhara		6.004
		(1.30)
Oromo		7.976
		(1.48)
Guraghe		0.218
		(0.04)
Other ethnic groups		-1.402
		(0.23)
Constant	44.41***	0.748
	(21.00)	(0.04)
R2	0.024	0.104
Adjusted R2	0.021	0.080
Number of observations	911	911

Note: Dependent variable: stated trust in instution. Standard errors are clustered at a trustor level. *, **, *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Model 1 confirms the descriptive statistics, where, in particular, the tax authority and the electric utility are sent lower amounts of money than the entrepreneurship development agency. In model 2, we introduce a battery of explanatory variables. The coefficients for tax authority and electricity utility remain statistically significant, and the magnitudes are not affected to any large extent. None of the institutional characteristics explains the amount that trustors send to the trustees. Among the trustor characteristics, only a few are statistically significant at the 5% level. If the business is located in an industry zone and if it has only one owner, then the amount sent is higher. Trustors who identify them-

selves as more risk-taking send more to the trustee. In addition, older trustors send more. The ethnicity of trustors does not significantly affect institutional trust. Trustors who are ethnic Amharas and Oromos (the two largest ethnic groups in Ethiopia) appear to have higher trust in the institutions compared with others, though both effects are not statistically significant.

3.2 Stated Trust

Table 6 shows the level of stated trust for six different groups of trustee categories: a resident of Addis Ababa, entrepreneur in the district, entrepreneurship development agency, district administration, tax authority and electric utility. In the last five categories we asked trust both towards employees at the institutions as well as institution per se.

TABLE 6: *Stated Trust in Institutions: Trust in Employees Working at the Institution and the Institution in General*

Trustee category	**Employees/Individuals**			**Institution in general**		**Signed-rank**
	Obs.	**Mean**	**Std. dev.**	**Mean**	**Std. dev.**	**p-values**
A resident of Addis Ababa	235	5.41	2.08	n/a	n/a	n/a
Entrepreneur in the district	235	5.51	2.11	5.47	2.32	0.330
Entrepreneurship dev. agency	235	5.53	2.41	5.86	2.69	0.004
District administration	235	5.18	2.38	5.24	2.73	0.239
Tax authority	235	4.98	2.27	5.40	2.62	0.001
Electric utility	235	4.56	2.29	4.90	2.71	0.034

The variation in stated trust shows the same pattern as the variation in transferred amount in the trust game, in the sense that the highest trust are for a random resident of Addis Ababa and an entrepreneur in the district, while the lowest trust is for the electric utility. We begin by comparing the stated trust in the employees and in the institution in general. The correlation coefficients are high for each institution: be-

tween 0.64 and 0.67. Thus, there is a substantial degree of correlation; meaning that institutional trust is linked with the trust in the individuals working at the institutions. The stated trust levels when subjects are asked about the institution are higher than when asked about the employees.

Next, we investigate whether there are observables that correlate with stated institutional trust in the same manner as we investigated amounts sent in the trust game as shown in Table 5. Again, we pool the responses for the four institutions. We use stated trust in the institution in general and the results are similar if we use stated trust in the employees (available upon request from the authors). The results are presented in Table 7.

TABLE 7: *Regression Analysis of Stated Trust in Institutions in General*

Variables	**(1)**	**(2)**
Institutions (base group = Entrepreneurship development agency)		
Tax authority	–0.530***	-0.351
	(2.61)	(0.62)
Electric utility	–1.097***	-0.821**
	(5.17)	(1.98)
District administration	–0.706***	-0.717*
	(3.44)	(1.68)
Institutions (Institutional characteristics)		
Average salary (in 1,000 birr)		-0.034
		(0.30)
Average age		-0.030
		(0.87)
Proportion of males		-0.162
		(0.23)
Proportion of employees with at least a college diploma		0.102
		(0.11)
Trustor characteristics)		
Age (in years)		-0.023
		(1.26)
At least a college diploma		-0.282
		(0.95)
Male		-0.626*
		(1.91)
Married		-0.350
		(1.14)
Risk preference		0.072

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Table 7 – *Continued from previous page*

Variables	**(1)**	**(2)**
		(1.59)
Business experience		0.045*
		(1.76)
Total number of employees		0.003
		(0.21)
Industry zone location		-0.263
		(0.86)
Monthly revenue (in 1,000 birr)		-0.002
		(1.39)
More than one owner		0.146
		(0.45)
Religion (base group = Christian Orthodox))		
Muslim		0.345
		(0.67)
Protestant		-0.162
		(0.52)
Ethnicity (base group = Tigray)))		
Amhara		0.229
		(0.53)
Oromo		1.128**
		(2.22)
Guraghe		0.877*
		(1.77)
Other ethnic groups		-0.086
		(0.16)
Constant	5.985***	7.765***
	(31.70)	(4.15)
R2	0.021	0.085
Adjusted R2	0.018	0.059
Number of observations	835	835

Note: Dependent variable: stated trust in institution. Standard errors are clustered at a trustor level. *, **, *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

None of the institutional characteristics are statistically significant. Stated trust in the electric utility and in the district administration are statistically significantly lower than stated trust in the development agency.

3.3 Comparison of Trust Game and Stated Trust

Let us now compare the trust game and stated trust in more detail. To begin with, we report correlation coefficients for both stated trust measures with the amount sent in the trust game in Table 8.

TABLE 8: *Correlation between Amounts Sent in the Trust Game and Stated Measures of Trust*

Institution	**Trust in the game and Stated trust in institutions in general**		**Trust in the game and Stated trust in the employees of the institutions**		**Trust in the game and Generalized trust**	
	Correlation	P-value	Correlation	P-value	Correlation	P-value
Entrepreneurship dev. agency	0.21	0.001	0.22	<0.001	0.11	0.103
District administration	0.27	<0.001	0.32	0.005	0.17	0.009
Tax authority	0.23	<0.001	0.19	0.002	0.14	0.029
Electric utility	0.37	<0.001	0.42	<0.001	0.17	0.008

The correlation coefficients between stated trust (for both the institution in general and employees) and amount sent in the trust game, which range between 0.19 and 0.42, are considerably smaller than the correlations between the two stated trust measures, which we found to range from 0.64 to 0.67. At the same time, they are all statistically significantly different from zero. Squaring the correlation coefficient yields the variance explained; thus, a correlation coefficient of 0.42 means that almost 18% of the variance is explained. If we compare these correlation coefficients with what has been reported in the literature regarding generalized trust and trust games, the correlations found here are still rather large. For example, Johansson-Stenman et al. (2013) found a correlation coefficient of 0.13 when comparing the proportion sent in a trust game and stated trust among Bangladesh subjects. Table 8 also shows that the correlation between generalized trust and trust in the experiment is considerably lower. It is almost half of the correlation found between the specific stated trust question and trust in the experiment.

Finally, in Table 9, we now include the stated trust measures in the regression models with the amount sent in the institutional trust game

as the dependent variable. In the first column, we report the results of model 2 from Table 5, but with a smaller sample, since we exclude subjects that did not answer all stated trust questions.[15]

TABLE 9: *Regression Analysis of Amount Sent in the Trust Game*

Variables	**(1)**	**(2)**	**(3)**
Institutions (base group = Entrepreneurship development agency)			
Tax authority	-7.836	-8.195	-8.732
	(1.33)	(1.03)	(1.53)
Electricity utility	-11.88***	-16.06**	-11.79***
	(2.91)	(2.59)	(2.90)
District administration	-2.043	-5.496	-2.584
	(0.47)	(0.88)	(0.61)
Stated trust)			
		(3.79)	
Stated trust district administration		3.557***	
		(4.86)	
Stated trust electric utility		3.829***	
		(6.04)	
Stated trust entrep. dev. agency		2.597***	
		(3.28)	
Generalized trust			1.868***
			(2.81)
Institution characteristics)			
Average salary (in 1,000 birr)	1.454	1.57	1.548
	(1.02)	(1.15)	(1.10)
Average age	0.116	0.209	0.056
	(0.28)	(0.53)	(0.14)
Proportion of males	10.10	10.211	8.725
	(1.27)	(1.33)	(1.12)
Prop. of employees with diploma	3.218	2.336	1.306
	(0.34)	(0.25)	(0.14)
Age (in years)	0.301*	0.372**	0.279
	(1.71)	(2.17)	(1.60)
At least a college diploma	0.114	0.849	1.342
	(0.03)	(0.26)	(0.40)
Male	-4.355	-2.511	-3.081
	(1.19)	(0.75)	(0.87)
Married	5.342	6.382*	4.215
	(1.58)	(1.94)	(1.28)
Risk preference	0.792*	0.55	0.386
	(1.66)	(1.23)	(0.79)
Business experience	-0.086	-0.232	-0.133
	(0.30)	(0.85)	(0.48)

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[15] In most cases, this is because they replied, "do not know"; although, one trustor refused to answer the questions.

Table 9 – *Continued from previous page*

Variables	**(1)**	**(2)**	**(3)**
Total number of employees	0.103	0.104	0.168
	(0.61)	(0.64)	(0.96)
Industry zone location	6.876**	7.675**	8.755**
	(1.99)	(2.46)	(2.55)
Monthly revenue (in 1,000 birr)	-0.014	-0.008	-0.013
	(0.65)	(0.40)	(0.63)
More than one owner	-8.09**	-8.56***	-8.62**
	(2.32)	(2.65)	(2.53)
Religion (base group = orthodox Christian)			
Muslim	2.943	1.716	1.409
	(0.49)	(0.30)	(0.23)
Protestant	3.478	3.89	2.11
	(0.7)	(0.79)	(0.42)
Ethnicity (base group = Tigray)			
Amhara (=1 if ethnically Amhara)	6.219	5.14	7.841*
	(1.26)	(1.11)	(1.69)
Oromo (=1 if ethnically Oromo)	7.41	3.507	8.933*
	(1.29)	(0.64)	(1.67)
Guraghe (=1 if ethnically Guraghe)	-0.818	-3.861	0.964
	(0.15)	(0.73)	(0.19)
Other ethnic groups	-0.822	-0.806	3.877
	(0.12)	(0.12)	(0.57)
Constant	5.885	-13.935	2.02
	(0.29)	(0.71)	(0.10)
R^2	0.103	0.183	0.125
Adjusted R^2	0.077	0.156	0.099
Number of observations	835	835	835

Note: Dependent variable: amount of money sent for each trustee in the trust game. Standard errors are clustered at the trustor level. *, **, *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Let us begin by comparing models 1 and 2 in Table 9. In model 2, we add the stated trust measures and all four stated trust measures are statistically significant.[16] Including stated trust results in an increase in the adjusted R^2 from 0.077 to 0.156, almost exactly a doubling of the predictive power of the model. We find the strongest correlation between the trust game and stated trust for the electric utility and the weakest for the entrepreneurship development agency.

[16]We conduct a joint significance test of the stated measures and we reject the null hypothesis that they are jointly different from zero by using an F-test (p-value $<$ 0.001).

Finally, we investigate the correlation between behaviors in the trust game and the generalized measure of trust. In model 3, we estimate a model where we include the generalized trust response instead of stated trust in institutions. The coefficient for generalized trust is positive and statistically significant. However, the coefficient is smaller than the corresponding ones for institutional stated trust, again indicating that the relationship between generalized trust and behavior in the institutional trust game is weaker. Including generalized trust results in an increase in the adjusted R^2 from 0.077 to 0.099, which is also a considerably smaller increase than when including stated trust in institutions.

4 Discussion

Trust has traditionally been measured by using generalized trust questions or trust games with a focus on investigating interpersonal trust and how trust affects economic growth that is, bonding or bridging trust. The objective of this paper is to contribute to the trust literature on measurement of linking trust, which defines relationships with others who are in a different power position. We measured trust in institutions by using both a novel institutional trust experiment with employees at government institutions as trustees and stated trust questions towards institutions in general and employees at institutions. Our context is entrepreneurs in Addis Ababa, Ethiopia, which is currently experiencing rapid economic growth and where entrepreneurs are important actors for this growth. Entrepreneurs act as the trustors in their frequent interaction with many different types of institutions, which can be classified as trustees.

We find rather strong evidence of convergent validity of the different measures in the sense that stated trust in a specific institution in general and employees therein are both positively correlated and statistically significant with the amount sent in a trust game to the employees of the same institution. Moreover, stated trust in the institution and the stated trust in employees at the institution are highly correlated as

expected. Thus, survey-based measures of institutional trust is correlated with behavior in a trust-game. On the other hand, we show that generalized trust, or trust measured, as the amount sent to a random individual, is only weakly correlated with institutional trust, although the correlation is still positive and statistically significant. Taken together, these findings have implications for how to elicit both stated trust and trust in trust games, and the takeaway messages are that trust should be measured domain-specific and that cost-effective stated trust measures are strongly correlated with experimental measures of institution trust. The importance of domain-specific trust has implications on the analyses of how trust affect different types of economic activities and outcomes. To be clear, we have not in this paper argued that there is one underlying single true measure of institution trust. Thus, the fact that the survey-based measure and the experiment-based measure are strongly correlated is not in itself evidence of criterion validity. Future research should explore this in more detail, i.e., to what extent are both these measures good measures of latent trust in institutions.

Overall, we find a low level of trust toward institutions. As these institutions provide services that are important for the survival and growth of firms, the low level of trust implies that these working relationships could be ineffective. In particular, firms could be suspicious of policies and technologies introduced by these institutions. They might also be reluctant to deliver on their civic and economic responsibilities, such as tax compliance and environmental protection, in light of the low levels of trust they hold for these institutions. Moreover, we find that entrepreneurs have different levels of trust in different institutions, with trust in our sample being lowest for the electric utility and the tax authority. This finding indicates that it is important to measure institution-specific trust.

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The Persistence of Energy Poverty: A Dynamic Probit Analysis*

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Abstract

This paper contributes to the growing literature on energy poverty in developing countries. We use a dynamic probit estimator on three rounds of panel data from urban Ethiopia to estimate a model of the probability of being energy poor and to investigate the persistence of energy poverty. We also study the impact of energy price inflation, which Ethiopia experienced 2007–2009, on energy use and energy poverty. We find strong evidence of state dependence in energy poverty. A household that is energy poor in one round is up to 16% more likely to be energy poor in the subsequent round. Dynamic probit regression results also suggest that an increase in the price of kerosene – the most important fuel for the urban poor – drives households into energy poverty. A fractional response estimator for panel data, which estimates the impact of energy prices on the proportion of energy obtained from clean sources, also supports the finding on the adverse impact of energy price inflation. Households responded to the significant rise in the price of kerosene by consuming a large amount of charcoal, which has been documented to have serious environmental, climate, and health consequences. Our results have significant implications for policies developed to reduce energy poverty, conserve biomass resources, and promote energy transition.

JEL Codes: Q40, Q41, Q42, Q48

Keywords: Energy Poverty, Kerosene Price, Dynamic Probit, Urban Ethiopia.

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1 Introduction

The countries that adopted the Sustainable Development Goals (SDGs) put universal access to affordable and clean energy as one of the goals to achieve by 2030 (Nations, 2015). Despite the ambitious goal, nearly half of the world's population and about 81% of households in sub-Saharan Africa (SSA) still rely on wood-based biomass energy (mostly fuelwood and charcoal) to meet their cooking needs (Sander et al., 2011). The use of biomass fuels, often burned in inefficient cookstoves, has serious impacts on the environment, the climate, and human health. Deforestation and forest degradation resulting from efforts to meet cooking energy needs have been the main cause of the loss of irreplaceable biodiversity and destruction of local ecosystems in many developing countries (Allen and Barnes, 1985; Geist and Lambin, 2002; Hofstad et al., 2009; Köhlin et al., 2011). Africa's tropical forests have significant carbon sequestration capacity, but are at greater risk than those in other parts of the world. In fact, they are disappearing three times faster than the world average (Mercer et al., 2011). The use of biomass fuel, often burned in inefficient cookstoves, contributes to climate change through emissions of harmful greenhouse gases, including black carbon and carbon dioxide (Grieshop et al., 2011; Kandlikar et al., 2009; Sagar and Kartha, 2007). Consequently, investigating the energy use behavior of households and the factors that reduce energy poverty and reliance on biomass fuel will have significant implications for environmental and climate policies.

The motivations for this paper are two-fold: first, we want to investigate the impact of energy prices on energy consumption and poverty. Urban Ethiopia is a valuable set-up for investigating the impact of rising energy prices. The country experienced rapid economic growth after 2004, with an average GDP per capita growth rate of 10.6% from 2004 to 2011 (Geiger and Goh, 2012). However, the double digit economic growth was accompanied with double digit inflation. From 2004 to 2009, i.e., the years when the last two rounds of the Ethiopian Urban Socioeconomic Survey (EUSS) panel data used in this paper were collected, the

price of cereals increased by 114%. The price of kerosene, the fuel used by a large proportion of the Ethiopian urban poor for cooking, increased by 177% (EUSS). In the 2009 survey, 74% of households reported energy price inflation as the second most important shock (after food price inflation) that affected their welfare during the analyzed period. Households in developing countries lack insurance from formal institutions. Instead, they try to cope with risk and shocks using informal mechanisms (Alem and Söderbom, 2012; Behrman et al., 1997; Dercon, 2004; Lim and Townsend, 1998; Rosenzweig and Wolpin, 1993; Skoufias and Quisumbing, 2005; Townsend, 1994). It is therefore highly relevant to investigate the strategies households adopted to cope with the energy price shock and their implications.

We attempt to investigate the behavioral response of households to energy price inflation using the most robust dynamic probit estimator, the Wooldridge Conditional Maximum Likelihood estimator (WCML), on three rounds of the EUSS panel data. The WCML estimator addresses the specific endogeneity problem known in non-linear dynamic estimators as the "initial conditions problem," i.e., endogeneity of the lagged dependent variable, by specifying an approximation for the density of household unobserved heterogeneity conditional on the initial period value of the dependent variable. The detailed energy consumption data in EUSS enables us to convert all energy types into comparable standard units in kilogram of oil equivalent (kgoe) and categorize each household into energy poor or non-poor based on alternative measures. Alternative dynamic probit regression results suggest that an increase in the price of kerosene leads to an increase in the likelihood of being energy poor.

Our results show that households responded to the rapid increase in the price of kerosene by using more charcoal to meet their cooking energy needs. We complement our analysis with results from a fractional response estimator for panel data (Papke and Wooldridge, 2008) that estimates the impact of a rise in energy prices on the proportion of energy derived from clean fuel in actual kgoe. The results confirm the findings from the dynamic probit estimator. An increase in the price of kerosene leads to a statistically significant reduction in the proportion

of actual energy derived from clean fuels. Such a shift to solid (biomass) fuel understandably has adverse implications on the health of household members, the climate, and the environment by contributing to deforestation and forest degradation.

Second, we want to investigate the persistence, trends, and correlates of energy poverty. The spatial and temporal distribution of energy poverty and its persistence is important information used by policymakers and other stakeholders aiming to promote transition to cleaner energy sources. Relying on the richness of the panel data at hand, we are able to compute alternative energy poverty measures (Modi, Barnes and the Multidimensional Energy Poverty Index – MEPI) and investigate the persistence of energy poverty and its correlates over time using dynamic probit estimators. We show that 22–60% of urban Ethiopian households have always been energy poor during the decade under analysis (2000–2009). More specifically, dynamic probit regression results suggest that a household that is energy poor in any given round is up to 16% more likely to remain in energy poverty in the subsequent round. The strong state dependence in energy poverty that we document has important implications for the development of policies targeting the persistently energy poor.

The rest of the paper is organized as follows: Section 2 presents the frontier literature on energy poverty. Section 3 describes the conceptual framework, which motivates our empirical strategy. Section 4 discusses the initial conditions problem and specifies a dynamic probit model for the probability of being energy poor. Section 6 presents the data and descriptive statistics, and Section 7 concludes the paper.

2 Related Literature

This paper contributes to the limited literature on measuring energy poverty that builds on the work of Foster et al. (2000), Pachauri et al. (2004), and Modi et al. (2005). Foster et al. (2000) offer one of the early contributions in measuring the extent of energy poverty by using the average energy consumption expenditure of households that are below the

monetary poverty line in Guatemala. This method assumes that those who are poor in money-metric measures are also energy poor. Pachauri et al. (2004) proposed an alternative measure – the energy access consumption matrix – which gives an indication of the level of access to final energy and the amount consumed by people at the national level. Using this two-dimensional approach, the authors documented that the status of energy poverty in India declined from 1983 to 2000. However, the method is better suited for investigating energy poverty using macro-level data.

Modi et al. (2005) proposed an approach that is more suitable for analysis at the micro level. These authors defined energy poverty as a lack of the minimum level of energy required for cooking and lighting. Employing a compressive approach, they document the essential role of energy services (such as cooking, heating, and electricity) in achieving the Millennium Development Goals (MDGs). Similarly, using cross-country data, Sovacool et al. (2012) examine the relationship between energy access and MDGs. Their study shows that energy poverty – associated with the use of biomass fuel – has dire environmental consequences including deforestation and changes in land use as well as emission of greenhouse gases.

Despite some attempts, less attention has been given to analyzing energy poverty in the world's poorest communities (Birol, 2007). In an attempt to fill the knowledge gap, Barnes et al. (2011) develop a demand-based approach where the energy poverty line is defined as the threshold at which energy consumption begins to rise with an increase in household income. Using cross-sectional data from Bangladesh, the authors show that there are more energy poor than income poor people (58% vs. 45%).

Recently, attention has been given to the multifaceted nature of energy poverty. Nussbaumer et al. (2012) proposed a multidimensional energy poverty index (MEPI) that takes into account the deprivation to modern energy services. They selected five dimension representing basic energy services: cooking, lighting, household appliances, entertainment/education and communication and examined the extent of energy

poverty in various African countries. Building on this, Ogwumike and Ozughalu (2016) constructed a simple multidimensional energy poverty index based on three dimensions: cooking, indoor pollution, and lighting. Using a logistic regression on the Nigerian Living Standard Survey data, these authors show that household size, age of household head, proportion of total consumption expenditure spent on food, and general poverty are positively correlated with energy poverty, while being female and being educated are negatively associated.

One key challenge in the existing energy poverty literature is that the results from different studies are not comparable because the energy poverty measures employed in the studies are not uniform. In this regard, Bensch (2013) used a unique household dataset from five sub-Saharan countries and finds that the different measures perform differently in terms of the identification of the energy poor, sensitivities to parameter changes, and data requirements.

Another point in the energy poverty literature worth noting is that, in developed countries, the definition and measures of energy poverty are quite different from those used in developing countries. In Europe, energy-poor households are those that are not able to adequately heat their homes or that spend more than 10% of their income on energy expenditures. Employing these definitions, Phimister et al. (2015) in Spain and Roberts et al. (2015) in the United Kingdom investigate the dynamics and persistence of energy poverty. Their studies show that there is less persistence in energy poverty than in income poverty, but more energy poverty persistence in urban areas than in rural areas (Roberts et al., 2015).

Our paper contributes to the literature by analyzing the trends and persistence of energy poverty and investigating the impact of energy price inflation using robust panel data estimators on a decade-long panel dataset from a developing country in the process of rapid economic growth. The richness of the panel data enables us to gauge energy poverty using alternative measures and investigate the robustness of our results.

3 Data and Descriptive Statistics

3.1 Data

We use three rounds of panel data from the Ethiopian Urban Socioeconomic Survey (EUSS) collected in 2000, 2004, and 2009. EUSS is a rich data set containing several socioeconomic variables at the individual and household level. The first two waves of the data used were collected by the Department of Economics of Addis Ababa University in collaboration with the University of Gothenburg, and cover seven of the country's major cities: the capital Addis Ababa, Awassa, Bahir Dar, Dessie, Dire Dawa, Jimma, and Mekelle.[1] Representativeness of the major socioeconomic characteristics of the Ethiopian urban population was taken into consideration when selecting the cities. About 1,500 households were distributed over the cities, in proportion to their population, and the sample households were recruited from half of the *kebelles* (the lowest administrative units) in all *woredas* (districts) in each city.

The last wave of the data (EUSS 2009) was collected by one of the authors in late 2008 and early 2009 from a sub-sample of the original sample in four cities (Addis Ababa, Awassa, Dessie, and Mekelle), comprising 709 households.[2] These cities were carefully selected to represent the major urban areas of the country and the original sample.[3] Of the 709 households surveyed, 128 were new, randomly chosen households incorporated into the sample. The new households were surveyed to address the concern that the group of panel households may have become unrepresentative since its formation in 1994. Alem and Söderbom (2012) address this and show that there is no systematic difference between the new households and the old panel households, which implies that the panel households represent urban Ethiopia reasonably well. In addition to a specific module on energy use, the data set contains detailed

[1] Data from these major urban areas were also collected in 1994, 1995, and 1997 (see AAU and GU (1995) for details on sampling). However, the waves before 2000 did not contain a module on energy use behavior.

[2] Other cities were not covered due to resource constraints.

[3] See Alem & Söderbom (2012) for a detailed description of EUSS - 2008/09.

information on households' living conditions, including income, expenditure, demographics, health, educational status, occupation, production activities, asset ownership, and other individual- and household-level variables.

Since the sample size of EUSS had to be reduced substantially in the most recent wave, it is reasonable to be concerned about bias in the estimation results as a result of attrition. Previous authors (Alem, 2015; Alem et al., 2014) who used the panel dataset for related research attempted to investigate attrition bias using attrition probits (Fitzgerald et al., 1998) and a Becketti, Gould, Lillard, and Welch (BGLW) test (Becketti et al., 1988). Attrition probits represent regression results of binary-choice models for the correlates of attrition in later periods as a function of baseline variables. The BGLW test, on the other hand, investigates the effect of future attrition on the initial period's outcome variable. Based on these tests, the authors conclude that it is less likely that attrition would bias the results for the remaining sample.

3.2 Measures of Energy Poverty

The energy module of EUSS contains detailed information on household energy purchase and consumption. Some of the fuel types are purchased and consumed in non-standard units. In order to obtain accurate and comparable data, we used carefully constructed conversion factors and converted energy consumed from all energy sources into a common unit of measurement of oil equivalent (kgoe). Besides, energy consumption, the data contains detailed information on income and asset ownership that allowed us to construct the three prominent measures of energy poverty used in the literature.

The first approach employed in the current paper to measuring energy poverty is the *minimum energy consumption threshold approach*. With this method, energy poverty is measured by counting the number of people consuming below the minimum level of energy consumption required to meet basic needs. To determine this level, we follow a procedure pro-

posed by Modi et al. (2005), who construct the energy poverty line based on per capita consumption of energy from modern sources. The modern energy sources used by households in our study are electricity, liquefied petroleum gas (LPG), and kerosene. We classify households based on their per capita modern energy consumption for both lighting and cooking. Following Modi et al. (2005), we use 50 kgoe as the energy poverty line for both cooking and lighting. Although this approach is easy to implement, it is difficult to agree on what a basic "necessity" is, which leads to having different thresholds depending on the country under consideration. Furthermore, this method is very stringent in that a household will be considered energy poor if it relies solely on biomass resources regardless of amount of energy consumed.

The second approach to measuring energy poverty used in the current study is proposed by Barnes et al. (2011). It is an alternative demand-based approach that defines the energy poverty line as the threshold at which energy consumption begins to rise with household income. Hence, it is known as *income-invariant energy demand or the minimum end-use energy (MEE)*. Following this approach, we compute the end-use energy by multiplying the total energy consumed by a conversion factor that is dependent on the type of stove and energy used by households. The Barnes approach identifies energy-poor households in two stages. First, the total end-use energy consumed by households is estimated by including income (wealth) deciles in the regression. Then the income decile at which wealth becomes significant is identified as an energy poverty line.[4] Households that are below the identified income threshold are classified as energy poor. One drawback of Barnes' measure, however, is that it does not encompass the complementary benefit of various energy services.

The third approach to measuring energy poverty that we consider in this paper is the *multidimensional energy poverty index* (MEPI), a more comprehensive method proposed by (Nussbaumer et al., 2012). MEPI

[4]The energy poverty line is robust to various changes, e.g., the inclusion of household size as one control variable, using real prices instead of nominal prices, including the price of dung cakes and plants.

is a measure that takes into account various aspects of energy poverty, specifically based on technological threshold or access to modern energy services. As access to modern energy services is not informative enough about a household's energy poverty status, various aspects beyond energy appliances should be considered (Nussbaumer et al., 2012).

Following Nussbaumer et al. (2012), we construct the index by investigating access to five dimensions. For each dimension, an energy deprivation cut-off was set where corresponding weights are attached to the selected indicator. The selected dimensions and their weights are: private electricity (0.2), exposure to indoor air pollution (0.3), modern cooking energy sources (0.2), cooling (0.133), electronic media (0.133), and communication (0.133). The deprivation matrix is set to be equal to the weight if the household is in the deprivation category (energy-poor) for a specific dimension. If not, it is equal to zero. The MEPI is equal to the sum of weighted deprivation-cut-off for each household. As in Nussbaumer et al. (2012), the multidimensional poverty line used in the paper is 0.3.

In a nutshell, we examine energy poverty in urban Ethiopia using three measures that focus on various aspects of energy consumption. Modi's measure is based on the absolute consumption from modern energy sources, while Barnes' measure relies on end-use energy (heat and luminous) obtained from different energy sources. Both of these measures depend on the level of energy consumption, while the third measure, MEPI, uses access to modern energy sources and appliances. Hence, using three measures that focus on different aspects of energy poverty enables us to capture the energy poverty status from different perspectives.

3.3 Descriptive Statistics

Figure 1 presents the incidence of energy poverty during the decade under analysis (2000–2009) using the three measures. The dynamic probit estimator, which we present in detail in Section 5, requires at least

three rounds of data for each household. About 434 households were observed in all three rounds, implying a total of 1,302 observations. Figure 1 shows that the incidence of energy poverty measured by all three methods declined from the base year, 2000, to 2009.

Figure 1: Trends in energy poverty, 2000–2009

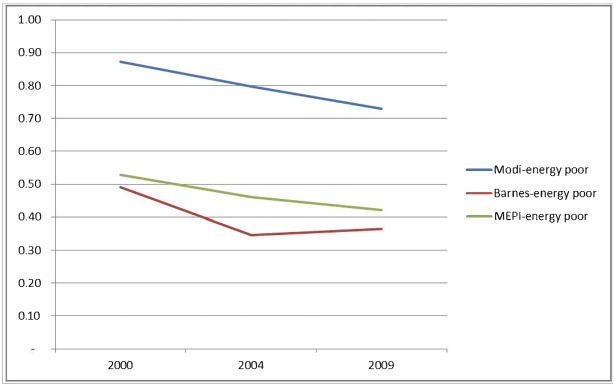

Table 1 presents descriptive statistics for the main variables used in the regression. We use real fuel prices, which are adjusted for temporal and spatial variation using price indices carefully constructed from the survey. Comparison with in 2000, the real fuel prices were higher in 2004 and lower in 2009, on average. However, the nominal prices show a significant increase from 2004 to 2009. In 2009, the descriptive statistics also show that the average age of the household heads is 55, and 30% of them did not have formal education. Moreover, the table shows that 72% of the sample come from Addis Ababa, which is the country's capital and also the city that has the largest share of the urban population in the country.

TABLE 1: *Descriptive statistics of variables, 2000-2009*

	[1]		[2]		[3]	
	[2000]		[2004]		[2009]	
	Mean	SD	Mean	SD	Mean	SD
Real Prices of Major Fuel Types						
Firewood (birr/kg)	0.854	0.607	1.111	0.755	0.406	0.222
Charcoal (birr/kg)	1.127	0.488	1.44	0.593	0.691	0.332
Kerosene (birr/liter)	2.159	1.002	2.451	0.774	2.444	0.887
Electricity (irr/kwh)	0.38	0.055	0.381	0.055	0.152	0.028
Head Characteristics						
Age	50.673	13.278	51.82	13.531	55.447	14.133
Female	0.433	0.496	0.477	0.5	0.495	0.501
No schooling	0.15	0.357	0.357	0.48	0.302	0.46
Primary school completed	0.3	0.459	0.242	0.429	0.297	0.458
Secondary or junior secondary school completed	0.505	0.501	0.32	0.467	0.286	0.452
Tertiary school completed	0.046	0.21	0.081	0.273	0.115	0.32
Out of the labor force	0.3	0.459	0.41	0.492	0.403	0.491
Employer or own-account worker	0.249	0.433	0.24	0.427	0.226	0.419
Civil or public servant	0.184	0.388	0.171	0.377	0.141	0.348
Private sector employee	0.09	0.286	0.078	0.269	0.12	0.325
Casual worker	0.099	0.299	0.065	0.246	0.071	0.258
Household Characteristics						
Proportion of females	0.325	0.215	0.335	0.213	0.365	0.233
Number of children members	1.885	1.595	1.498	1.348	1.005	1.123
Number of elderly members	0.053	0.287	0.028	0.178	0.06	0.256
Log of real consumption per adult equivalent	4.631	0.820	4.72	0.746	4.777	0.674
Location						
Addis	0.724	0.448	0.724	0.448	0.724	0.448
Awassa	0.083	0.276	0.083	0.276	0.083	0.276
Dessie	0.099	0.299	0.099	0.299	0.099	0.299
Mekelle	0.094	0.293	0.094	0.293	0.094	0.293
Observations	434		434		434	

Notes: Columns [1], [2] & [3] of this table present summary statistics (means and standard deviations) for key variables from EUSS conducted in 2000, 2004 and 2009.

Table 2 reports the number of times that a household has been classified as energy poor. Based on Modi's measure, 60% of the sample have been energy poor in all three rounds while this figure drops to 26% and 22% when using MEPI and Barnes' measure of energy poverty, respectively. On the other hand, the percentage of households that are not classified as energy poor in any of the three rounds varies from 5% using Modi's measure to 40% using Barnes' measure.

TABLE 2: *Persistence of energy poverty*

		[1]	[2]	[3]	[4]	[5]
		Never poor	Poor once	Poor twice	Always poor	Total
Modi poor	Frequency	60	132	336	774	1,302
	Percentage	4.61	10.14	25.81	59.45	100.00
Barnes poor	Frequency	522	282	213	285	1,302
	Percentage	40.09	21.66	16.36	21.89	100.00
MEPI poor	Frequency	459	198	297	348	1,302
	Percentage	35.25	15.21	22.81	26.73	100.00

Notes: Columns [1]–[4] present summary statistics on the number of households that were classified as energy poor across the three rounds based on energy poverty data constructed from EUSS 2000–2009.

4 Conceptual Framework

In this section, we provide a theoretical framework that can serve as a basis for the main empirical analysis conducted in this paper. Our outcome variable of interest – energy poverty – has been constructed from consumption levels of the various fuel sources, which originate from the household's fuel choice decision. A household's demand for fuel is a related decision to the demand for durable cooking appliances (Dubin and McFadden, 1984). Therefore, we illustrate that the levels of consumption of energy from different fuel sources can be derived using a simple utility maximization framework once the households adopt an energy appliance. Therefore, we start with the demand functions for appliances, which is shown can be obtained from maximization of a utility function (Dubin and McFadden, 1984).

For simplicity, we focus on a single fuel type, electricity, but the framework can be generalized to all fuel types. In our context, households will have a positive demand for electricity for cooking purposes only if they possesses an electric appliance that can be used for cooking, i.e., either a so-called *electric mitad* or an *electric stove*.[5] Since the utility obtained from an electric appliance originates from the flow services it provides, the utility can only be observed indirectly.

[5] An electric mitad is used for baking the staple food injera, while electric stoves are used for preparing stew.

Dubin and McFadden (1984) framework considers a consumer/household that faces a choice of m mutually exclusive appliances, which can be indexed as $i = 1, ...m$, and appliance i has a cost (rental price) of r_i. The conditional indirect utility for appliance i is given as follows:

$$u = V(i, y - r_i, p_1, p_2, s_i, \epsilon_i, \eta) \tag{1}$$

where p_1 is the price of the fuel for appliance i, which is electricity in our case, p_2 represents prices of alternative energy sources for appliance i, s_i and ϵ_i denote the observed and unobserved attributes of the appliance, respectively, and η is unobserved characteristics of the consumer.

The household will choose appliance i over alternative j if

$$V(i, y - r_i, p_i, \mathbf{p}_k, s_i, \epsilon_i, \eta) > V(j, y - r_j, p_j, \mathbf{p}_k, s_j, \epsilon_j, \eta) \tag{2}$$

Given the indirect utility function specified in equation 1, the consumption level for the fuel required for appliance i (electricity) can be obtained using Roy's identity.

$$x_i = -\frac{\partial V(i, y - r_i, p_i, \mathbf{p}_2, s_i, \epsilon_i, \eta)/\partial p_i}{\partial V(i, y - r_i, p_i, \mathbf{p}_2, s_i, \epsilon_i, \eta)/\partial y} \tag{3}$$

Even though one could derive the level of consumption of a particular fuel using adoption models for appliances, such specifications would fail to capture the consumption pattern after the energy appliance has been adopted. In addition, they would not show whether the demand for a specific fuel type is influenced by the price of appliances needed for alternative energy sources.

However, we assume that once a household has adopted a specific appliance, it will decide on the type and amount of fuel it will use for all of its appliances. Consequently, unlike the utility obtained from appliances, the utility from using different fuel sources can be modeled directly.

We consider a household that faces a choice of m mutually exclusive fuel types, which can be indexed as $i = 1, ...m$, and $p_i$represents the market

price of the i^{th} fuel type x. Thus, the household's utility maximization problem can be given as follows:

$$\begin{gathered} \text{Max } U = f(p_1, p_2..., p_m, h_i, \eta) \\ \text{Subj. } M = p_2 x_2 + ...p_m x_m \end{gathered}$$

where M is household income, h_i denotes household and household head characteristics, and η represents the economic conditions of the specific geographical area that may influence fuel choices. Taking the energy appliance that households adopt as given and the utility maximization specified above, the household decides on the consumption level of each fuel type. We use these consumption levels to classify households into energy poor and energy non-poor in the first analysis and to compute the fraction of clean energy used in the second analysis.

5 Empirical Strategy

5.1 Energy Poverty Persistence - A Dynamic Probit Estimator

We draw on the standard poverty transition and persistence literature (Biewen, 2009; Duncan et al., 1993; Oxley et al., 2000) and model energy poverty using a dynamic probit specification. Poverty status is modelled in a dynamic framework because of state dependence, i.e., an individual or household that is poor in any given period is more likely to be poor in the next period. In order to analyze the underlying causes of energy poverty persistence, we therefore specify a general dynamic probit model as follows:

$$g_{it}^{*} = \gamma g_{it-1} + x_{it}^{\prime}\beta + c_i + u_{it} \tag{4}$$

$(i = 1, ..., N; t = 2, ..., T)$, where g_{it}^* is a latent dependent variable; g_{it} is the observed binary outcome variable defined as

$$g_{it} = 1[g_{it}^* \geq 0], \quad t = 2, ..., T, \tag{5}$$

g_{it-1} represents energy poverty status in the previous period, x_{it} represents a vector of explanatory variables, c_i is a term capturing unobserved household heterogeneity, and u_{it} is a normally distributed error term with mean zero and variance normalized to one. The subscripts i and t refer to cross-sectional units (households in our case) and time periods (rounds), respectively. The number of cross-sectional units, N is assumed to be large, but the numbers of time the cross-sectional units are observed, T is small, which implies that asymptotics depend on N alone. Modeling this relationship in the standard random effects probit framework implicitly assumes that, conditional x_{it}, c_i is normally distributed with mean zero and variance σ_c^2, and independent of u_{it} and x_{it}.

Thus, under the above assumptions, the transition probability for household i at time t, given c_i, is therefore given by

$$Pr(g_{it}|x_{it}, g_{it-1}, c_i) = \Phi\{(\gamma g_{it-1} + x_{it}'\beta + c_i)(2g_{it} - 1)\}, \tag{6}$$

where Φ is the cumulative distribution function of the standard normal distribution.

In order to estimate the dynamic probit model specified above, one needs to make assumptions about initial energy poverty status g_{i1}, i.e., the energy poverty status of a household at the start of the panel, and its correlation with the unobserved heterogeneity term c_i. If one assumes that the initial energy poverty status is exogenous, the standard random effects probit estimator can be used to estimate the model. However, such an assumption is unrealistic because the poverty status of households, g_{it}, s not observed from its start, and hence simply assuming it is exogenous and estimating it using the random effects probit estimator

would result in biased parameter estimates. This implies that the lagged poverty status, g_{it-1}, will be correlated with c_i. The resulting estimation problem is known in the applied economics literature as the *initial conditions problem*. Estimating the model consistently therefore requires integrating out the unobserved heterogeneity term c_i.

The first estimator that addresses the initial conditions problem encountered in estimating the dynamic probit model specified above was suggested by Heckman (1981),who proposed a two-step maximum likelihood estimator. Heckman's method begins by specifying a linearized reduced form equation for the initial value of the latent variable, which includes exogenous instruments and initial values of the right-hand side variables. The reduced equation can then be incorporated in the likelihood function of each observational unit, and the Guauss-Hermite quadrature approach (Butler and Moffitt, 1982) can be applied to evaluate the integral in the likelihood function. This estimator yields consistent parameter estimates provided the latent equation time-varying error terms are serially uncorrelated (Stewart, 2006). However, Heckman's estimator has not been used much in applied research due to its absence in standard software and huge computational cost.

Later on, Wooldridge (2005) proposed a conditional maximum likelihood estimator, which begins by specifying the joint density for the observed sequence of the outcome variable of interest $(g_2, g_3, ..., g_T|p_1)$ as $(g_T, g_{T-1}, ..., g_2|g_1, x, c)$. Next it specifies an approximation of the density of c_i, conditional on the initial value of the outcome variable g_1, which makes it convenient to integrate it out from the main equation. Wooldridge specifically proposes the following specification for the unobserved heterogeneity term, c_i:

$$c_i|g_{i1}, z_i \sim N(\zeta_0 + \zeta_1 g_{i1} + z_i'\zeta, \sigma_a^2), \tag{7}$$

where

$$c_i = \zeta_0 + \zeta_1 g_{i1} + z_i'\zeta + a_i \tag{8}$$

The specification in equation 8 takes care of the correlation between g_{i1} and c_i and gives rise to a new unobserved heterogeneity term a_i that is uncorrelated with the initial period outcome variable g_{i1}. Substituting equation 8 into equation 6 yields

$$Pr(g_{it} = 1|a_i, g_{i1}) = \Phi[x_{it}'\beta + \gamma g_{it-1} + \zeta_0 + \zeta_1 g_{i1} + z_i'\zeta + a_i] \qquad t = 2, ..., T. \tag{9}$$

The likelihood function for household i is therefore given by

$$L_i = \int \{\prod_{t=2}^{T} \Phi[(x_{it}'\beta + \gamma g_{it-1} + \zeta_0 + \zeta_1 g_{i1} + z_i'\zeta + a)(2g_{it} - 1)]\} f^*(a)da, \tag{10}$$

where $f^*(a)$ is the normal probability density function of the new unobservable term a_i introduced in equation 7. Like the two-step estimator proposed by Heckman, this estimator, known as the Wooldridge Conditional Maximum Likelihood (WCML) estimator, can be generalized allow for the error term in the initial period equation to be freely correlated with errors in subsequent time periods. By controlling for period-specific x variables, this estimator, just like Mundlak (1978), also allows for correlation between the explanatory variables, x_{it} and the unobserved heterogeneity term, c_i, an approach, which makes it conveniently implementable in a random effects probit framework. Estimating the WCML estimator in standard software packages is straightforward.[6] We use the estimator to analyze the persistence of energy poverty in urban Ethiopia.

5.2 Fuel Substitution – A Fractional Response Estimator

In order to shed light on the channels behind the change in the status of energy poverty following changes in energy prices, we estimate a fractional response model (FRM) (Papke and Wooldridge, 2008). The frac-

[6]The estimator is implemented using the *xtprobit* command in Stata.

tional response model (FRM) enables us to answer the question of how the proportion of clean energy used by households changes in response to price. Our outcome variable of interest is the proportion of energy in kilojoules obtained from clean fuels, namely kerosene, liquefied petroleum gas (LPG), and electricity, run as a function of prices and other covariates. When the dependent variable is bounded between zero and one, as in our case, using linear specifications for the conditional mean might miss important nonlinearities (Papke and Wooldridge, 1996). Even applying a log-odds transformation would fail when one observes corner responses (0 and 1). In addition, not even when the dependent variable is strictly inside the interval is it possible to recover the expected value of the fractional response model unless one makes strong independence assumptions. Papke and Wooldridge (1996)propose an extension of the generalized linear model (GLM) that keeps the predicted value in the unit interval and overcomes the drawbacks associated with using the log-odds transformation. These authors also introduce a Ramsey RESET test for correct specification of the mean function. This is crucial because their model is robust only if the mean function is correctly specified. Moreover, using the fractional logit model in panel data will not provide correct parameter estimates as the standard errors are not robust to arbitrary serial correlation and the conditional variance is misspecified (Papke and Wooldridge, 2008).

Papke and Wooldridge (2008)introduced a quasi-maximum likelihood estimator (QMLE) that extends their fractional response model for cross-sectional data to panel data. In the panel version of FRM, for each random draw of i, we have T observations $t = 1, 2...T$, and the response variable y_{it}, $0 \leq y_{it} \leq 1$. We first make a functional form assumption for a set of explanatory variables, x_{it}, a $1 \times K$ vector where

$$E\left(y_{it}|x_{it},c_i\right) = \Phi\left(x_{it}\beta + c_i\right), t = 1, ...T \tag{11}$$

where Φ is standard normal cumulative distribution function. This assumption of a probit functional form renders simple estimators in the presence of unobserved individual heterogeneity and endogenous ex-

planatory variables. Even in the case where y_{it} is a binary variable, the conditional logit model would not be suitable to estimate β because there could be serial correlation in the response variable. By employing probit response functions, Papke and Wooldridge (2008)'s approach has the added advantage of readily estimating average partial effects.

As Φ is strictly monotonic, ignoring the subscript i, the partial effects are given as follows. In the case where$\times_{tj}$ continuous,

$$\frac{E\left(y_t|\mathbf{x}_t,c\right)}{\times_{tj}} = \beta_j \phi\left(\mathbf{x}_t\beta + c\right) \tag{12}$$

And a discrete change in the explanatory variable is given as:

$$\Phi\left(\mathbf{x}_t^{(1)}\beta + c\right) - \Phi\left(\mathbf{x}_t^{(0)}\beta + c\right) \tag{13}$$

where $\mathbf{x}_t^{(0)}$ and $\mathbf{x}_t^{(1)}$ are two different values.

However, as shown in equations (12) and (13), the average partial effects (APEs) are not identified as they depend on the unobserved heterogeneity (c). In order to identify both β and the APEs, two additional assumptions are required.

Assumption 1: Conditional on $c_i, [\mathbf{x}_{it} : t = 1, ...T]$ is strictly exogenous

$$E\left(y_{it}|\mathbf{x}_i,c_i\right) = E\left(y_{it}|\mathbf{x}_{it},c_i\right), t = 1, ...T. \tag{14}$$

Assumption 2: The conditional normality assumption proposed by Chamberlain (1980)

$$c_i|\mathbf{x}_{i1,}\mathbf{x}_{i2,....}\mathbf{x}_{iT} \sim N\left(\psi + \overline{\mathbf{x}}_i\xi, \sigma_a^2\right) \tag{15}$$

where $\overline{\mathbf{x}}_i = T^{-1} \sum_{t=1}^{T} x_{it}$ is a $1 \times K$ vector of time averages. Having made the above assumptions, the partial effects are identified under no assumption of serial dependence in the response function while allowing the endogenous explanatory variables to be correlated with unobserved shocks in other time periods. In addition, Papke and Wooldridge (2008)'s approach allows for correlation between the time-invariant unobserved effects and the explanatory variables, which is the main concern while using a probit response function with panel data. Instead of treating the unobserved effects as parameters to be estimated, the authors combine Mudlak-Chamberlain's approach of modeling unobserved heterogeneity with the control function method, which produces consistent parameter estimates.

6 Results

Based on the three types of energy poverty measures, Table 3 presents marginal effects for a model of the probability of being energy poor as given by Equation (1). All marginal effects are computed from a random effects probit model, which controls for unobserved household heterogeneity but treats initial conditions as exogenous. In all regressions, we control for time and city fixed effects. The results suggest that there is strong state dependence on energy poverty. Columns [2] and [3] show that a household that is energy poor in any given round is about 8.8%, 28%, and 24.9% likely to be energy poor in the subsequent round according to the Modi, Barnes, and MEPI measures, respectively. The results also suggest that an increase in the price of kerosene – the most commonly used fuel type by urban Ethiopian households – leads to a rise in energy poverty in all regressions. Given that the random effects estimator does not correct for the initial conditions problem and very likely overestimates the persistence of energy poverty, we do not discuss this findings further.

TABLE 3: *Correlates of Energy Poverty – Marginal Effects from Random Effects Probit Regressions*

Variables	[1] Modi_poor	[2] Barne's_poor	[3] MEPI_poor
Lagged poverty	0.088***	0.280***	0.249***
	(0.029)	(0.023)	(0.024)
Firewood log price	0.048**	0.042*	0.023
	(0.024)	(0.024)	(0.025)
Charcoal log price	-0.013	0.016	-0.034
	(0.030)	(0.033)	(0.034)
Kerosene log price	0.121***	0.180***	0.189***
	(0.044)	(0.046)	(0.047)
Electricity log price	-0.067	0.094	-0.010
	(0.072)	(0.080)	(0.081)
Head, age	-0.001	-0.003**	-0.003**
	(0.001)	(0.001)	(0.001)
Head, female	-0.049	-0.021	-0.053
	(0.031)	(0.033)	(0.034)
Head, primary school completed	-0.083**	-0.051	-0.099***
	(0.037)	(0.033)	(0.034)
Head, secondary or junior secondary school completed	-0.163***	-0.165***	-0.204***
	(0.043)	(0.040)	(0.041)
Head, tertiary school completed	-0.271***	-0.205***	-0.251***
	(0.068)	(0.053)	(0.054)
Head, employer and own account-worker	0.037	0.019	-0.025
	(0.032)	(0.035)	(0.036)
Head, civil or public servant	0.046	0.022	-0.008
	(0.035)	(0.048)	(0.048)
Head, private sector employee	0.041	0.074	-0.008
	(0.042)	(0.053)	(0.053)
Head, casual worker	0.143***	0.097	-0.021
	(0.044)	(0.059)	(0.058)
Proportion of females	-0.002	-0.017	-0.052
	(0.061)	(0.067)	(0.070)
Number of children members	0.045***	-0.032**	-0.025*
	(0.013)	(0.013)	(0.013)
Number of elderly members	0.023	0.085	-0.009
	(0.051)	(0.059)	(0.068)
Log of real cons. per adult equivalents	-0.201***	-0.129***	-0.099***
	(0.019)	(0.022)	(0.022)
Round Fixed Effects	Yes	Yes	Yes
City Fixed Effects	Yes	Yes	Yes
Observations	868	868	868

Notes: Columns [1], [2] & [3] of this table presents marginal effects from random effects probit estimators for the correlates of energy poverty measured by the three indicators (Modi's, Barnes' and Multidimensional Poverty Index (MPI)) respectively with real energy prices. Standard errors in parentheses. ***, ** and * denote significance at the 1, 5 and 10% levels, respectively.

Table 4 presents marginal effects from the WCML estimator for the three energy poverty measures. The WCML estimator addresses the initial conditions problem robustly using the time-varying x variables in the z vector. The coefficient of the energy poverty persistence variable (the lagged dependent variable) declines from 0.08 to 0.04 in the case of the Modi measure, from 0.28 to 0.16 in the case of the Barnes measure,

and from 0.25 to 0.09 for the MEPI measure. This corresponds to a decrease in the marginal effects of about 50%, 42%, and 64% for the three energy poverty regressions, respectively. However, the lagged poverty is not statistically significant in the Modi measure. Consequently, we focus on the dynamic probit regression results from using Barnes' and the MEPI measures (columns [2] & [3]). The initial energy poverty status is not only statistically significant but also large in magnitude, in fact even larger than the coefficient of the lagged dependent variable in the case of the MEPI measure. This provides strong evidence in favor of controlling for endogeneity of the initial conditions problem.

TABLE 4: *Correlates of Energy Poverty - Marginal Effects from WCML Estimator*

Variables	[1] Modi_poor	[2] Barne's_poor	[3] MEPI_poor
Lagged Poverty	0.040	0.164**	0.098***
	(0.035)	(0.080)	(0.037)
Initial poverty status (2000)	0.092**	0.148**	0.211***
	(0.037)	(0.070)	(0.037)
Firewood log price	0.050**	0.042*	0.030
	(0.024)	(0.025)	(0.025)
Charcoal log price	-0.012	0.016	-0.036
	(0.030)	(0.034)	(0.033)
Kerosene log price	0.117***	0.179***	0.176***
	(0.044)	(0.047)	(0.046)
Electricity log price	-0.056	0.112	-0.025
	(0.072)	(0.080)	(0.080)
Head, age	-0.001	-0.003**	-0.003**
	(0.001)	(0.001)	(0.001)
Head, female	-0.048	-0.023	-0.061*
	(0.031)	(0.034)	(0.033)
Head, primary school completed	-0.082**	-0.038	-0.081**
	(0.037)	(0.034)	(0.034)
Head, secondary or junior sec. school completed	-0.164***	-0.159***	-0.183***
	(0.043)	(0.041)	(0.042)
Head, tertiary school completed	-0.270***	-0.196***	-0.211***
	(0.068)	(0.055)	(0.058)
Head, employer and own account-worker	0.037	0.016	-0.024
	(0.032)	(0.036)	(0.035)
Head, civil or public servant	0.048	0.025	-0.030
	(0.035)	(0.048)	(0.047)
Head, private sector employee	0.039	0.079	-0.023
	(0.042)	(0.053)	(0.051)
Head, casual worker	0.143***	0.092	-0.009
	(0.044)	(0.059)	(0.057)
Proportion of females	-0.007	-0.020	-0.038
	(0.061)	(0.068)	(0.068)
Number of children members	0.046***	-0.035***	-0.023*
	(0.013)	(0.013)	(0.013)
Number of elderly members	0.026	0.087	-0.015
	(0.051)	(0.060)	(0.067)
Log of real cons. per adult equivalents	-0.197***	-0.123***	-0.091***
	(0.019)	(0.022)	(0.021)
Round Fixed Effects	Yes	Yes	Yes
City Fixed Effects	Yes	Yes	Yes
Observations	868	868	868

Notes: Columns [1], [2] & [3] of this table presents marginal effects from the Wooldridge Conditional Maximum Likelihood (WCML) estimator on the correlates of energy poverty measured by the three indicators (Modi's, Barnes' and Multidimensional Energy Poverty Index – MEPI), respectively, with real energy prices. Standard errors in parentheses. ***, ** and * denote significance at the 1, 5, and 10% levels, respectively.

We observe a large state dependence in energy poverty in urban Ethiopia. Columns [2] and [3] of Table 4 indicate that a household that is energy poor in a given period has a 16% and 10% likelihood of remaining energy poor in the subsequent period. This is consistent with existing literature on poverty persistence in both developed and developing countries. The

high purchase price for modern cooking appliances and lack of access to micro-credits (Alem et al., 2017; Edwards and Langpap, 2005; Lewis and Pattanayak, 2012) for acquiring them are likely two key obstacles to adoption of modern energy appliances that use clean energy sources. Consequently, a large majority of households continue to use cheap and inefficient cookstoves that use solid (biomass) fuel. Such energy use behavior, directly contributes to the persistence of energy poverty.

The results also reveal the strong impact of energy prices on energy poverty.[7],[8] Energy prices are exogenous to households as they are determined by market forces, and by international prices in the case of kerosene – the most important cooking energy source for households in urban Ethiopia.[9] All the dynamic probit regression results reported in Table 4 show that a rise in the price of kerosene leads to an increase in energy poverty. Although the three measures of energy poverty differ in their construction, the coefficient of kerosene price is statistically significant at 1% for all of them (and the coefficients in the Barnes and MEPI dynamic probit regressions are almost identical). More specifically, a 10% increase in the price of kerosene leads to an increase of about 1.8% in energy poverty measured by the Barnes and MEPI measures. These results have important implications for policies aimed to reduce energy poverty and promote energy transition. EUSS shows that from 2004 to 2009, the average price of kerosene increased by 177%. Consequently, in the 2009 survey, around 74% of urban Ethiopian households reported it to be the second most important shock (after food price inflation) to adversely affect their welfare.

We further investigate the consequences of the large increase in the price of kerosene in urban Ethiopia. Figure 2 shows the average nominal price of all four fuel types in urban Ethiopia for the three rounds of panel

[7]There is large temporal and spatial variation in energy prices across Ethiopia. Appendix Figure A.1 presents the price variation in Addis Ababa.

[8]8Results reported in Appendix B show that the findings do not change when we use nominal prices instead.

[9]Ethiopia almost exclusively buys petroleum products from the international market. In 2008/09 alone, Ethiopia imported 1,971.9 million metric ton of petroleum products (NBE, 2009). The value of petroleum import is comparable to 60–160% of the total export earning between 2000/01 and 2009/10 (Andualem et al., 2014).

data collected. The average price of firewood, charcoal, and electricity did not change significantly during the period of analysis. However, the average price of kerosene increased from around 2.7 birr to around 7.6 birr in 2009. This corresponds to an increase of about 177%.[10] In Figure 3, we investigate the implications of rising kerosene prices on energy use by households in Ethiopia. As can be seen, there was a rapid increase in the amount of charcoal used during the period of inflation. The average quantity of charcoal consumed by households grew from around 14 kg/month in 2004 to around 24 kg/month in 2009, corresponding to a 71% increase. The rapid increase in charcoal consumption during the period suggests that households in urban Ethiopia responded to the unprecedented increase in the price of the key fuel, kerosene, by consuming more charcoal to meet their increased energy needs. The use of charcoal to meet the cooking energy needs is one of the prime causes of deforestation and forest degradation in Africa (Allen and Barnes, 1985; Geist and Lambin, 2002; Hofstad et al., 2009; Köhlin et al., 2011).

A closer look at the price differences between the different fuel sources and their consumption offers striking insights. In 2009, 1 kgoe of energy from electricity cost around 6 birr, while the same amount of energy from kerosene cost 9 birr. In addition, the real price of electricity halved from 2004 to 2009, while it remained fairly constant for kerosene. Despite these glaring differences, the observed increase in consumption of electricity in 2009 was not significant. One factor explaining this situation is the significant difference in purchase price between a kerosene stove and an electric stove. Electric cookstoves cost much more than kerosene stoves, which likely explains the lack of a significant shift to electricity.[11] The phenomenon of a large increase in the price of kerosene, but almost no increase in the price of electricity has significant income distribution implications. Only the rich, who constitute less than 5% the urban population, are able to acquire expensive cooking appliances and benefit

[10] A similar pattern is observed when we use median prices in each year. The figures are presented in Appendix A.2 and A.3

[11] The average market price of a standard electric mitad (stove) used to cook the staple food Injera cost about USD 97 in 2009. The equivalent biomass fuel mitad cost only 7.8% of the cost of the electric mitad, i.e., only about USD 8.

from lower electricity prices. In contrast, the rapid increase in the price of kerosene has forced the population in the lower part of the income distribution to shift to harmful biomass fuels, such as charcoal.

Figure 2: Trends in mean nominal energy prices

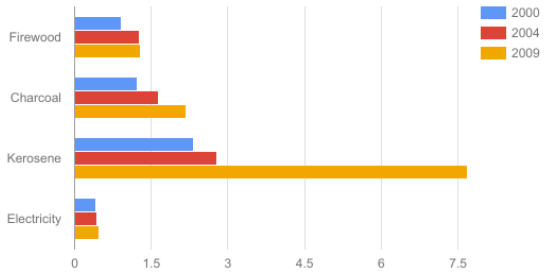

Figure 3: Trends in mean energy consumption in standard units

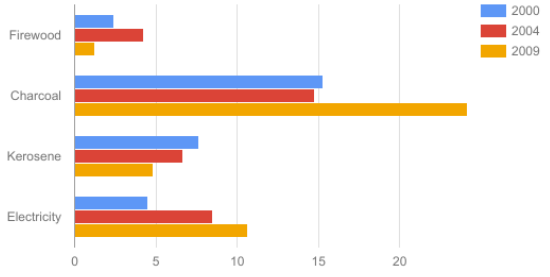

Table 4 also shows that education is negatively associated with the probability of being energy poor. Compared with household heads with no formal education, those who have primary, secondary, or tertiary education have a lower likelihood of being energy poor and the difference is statistically significant. Households with a higher economic status as measured by the log of real consumption expenditure per adult equiva-

lents are also less likely to be energy poor. However, it is important to note that all these variables – unlike the energy prices – are likely to be endogenous. Consequently, these associations (correlations) should not be considered to be causal.

Table 5, which reports regression results from a fractional response estimator, offers additional insights on how the increase in key energy prices, most importantly in the price of kerosene, has influenced the proportion of clean energy used by households. The results suggest that, among all studied fuel sources, the price of kerosene has the largest impact on the proportion of energy obtained from clean energy sources. More specifically, a 10% increase in the price of kerosene led to a 1.4% decline in the proportion of clean energy used by households. This is intuitive and consistent with the descriptive results presented in the preceding sections, because the increase in the price of kerosene – a relatively clean energy source, at least compared with biomass fuel sources – prompts households to switch to biomass fuel sources, all other factors constant. This reduces the proportion of energy obtained from clean sources and increases the proportion from dirty sources. The results also show that the increase in the prices of firewood and charcoal leads to a statistically significant increase in the proportion of energy obtained from clean sources, because households will likely switch to cleaner energy sources such as kerosene.

Consistent with the findings for the WCML estimator reported in Table 4, the fractional response estimator results reported in Table 5 show that higher education level of the household head, higher economic status as measured by the log of real consumption per adult equivalent and having a larger proportion of females in the household are all associated with a larger proportion of clean energy use. In contrast, being headed by a self-employed worker or a casual worker are both negatively associated with the proportion of clean energy use. These results are intuitive because the variable captures better awareness of the different fuel types available and stronger financial capacity to acquire and use clean energy sources and appliances. However, the results should be interpreted with caution as these variables are likely to be endogenous.

TABLE 5: *Energy prices and household energy use: Results from a Fractional Response Estimator*

	[1]	[2]
Variables	OLS	GLM Marginal effects
Firewood log price	0.059***	0.050***
	(0.012)	(0.012)
Charcoal log price	0.103***	0.107***
	(0.019)	(0.018)
Kerosene log price	-0.158***	-0.141***
	(0.028)	(0.027)
Electricity log price	-0.072	-0.089**
	(0.047)	(0.044)
Head, age	-0.001	-0.001
	(0.001)	(0.001)
Head, female	-0.026	-0.034
	(0.020)	(0.021)
Head, primary school completed	0.038*	0.028
	(0.023)	(0.024)
Head, secondary or junior sec. school completed	0.062***	0.044*
	(0.024)	(0.024)
Head, tertiary school completed	0.142***	0.112***
	(0.035)	(0.036)
Head, employer and own account-worker	-0.041*	-0.047**
	(0.022)	(0.022)
Head, civil or public servant	0.015	0.016
	(0.027)	(0.030)
Head, private sector employee	-0.037	-0.041
	(0.030)	(0.031)
Head, casual worker	-0.073**	-0.070*
	(0.034)	(0.036)
Proportion of females	0.109**	0.088*
	(0.045)	(0.046)
Number of children members	-0.004	-0.005
	(0.007)	(0.008)
Number of elderly members	0.013	0.005
	(0.035)	(0.031)
Round Fixed Effects	Yes	Yes
City Fixed Effects	Yes	Yes
Observations	1,302	1,302

Notes: Columns [1] & [2] of this table present regression results from a fractional response estimator on the correlates of the proportion of energy in kilogram oil equivalent units obtained from clean energy sources, with real energy prices. Robust standard errors in parentheses. ***, **, and * denote significance at the 1, 5, and 10% levels, respectively.

7 Conclusions

This paper investigates the persistence of energy poverty and the impact of energy price inflation on energy poverty in urban Ethiopia. Taking advantage of detailed panel data that spans a decade, namely the Ethiopian Urban Socioeconomic Survey (EUSS), we convert all energy consumed by households to comparable kilogram oil equivalents (kgoe) and compute energy poverty based on three popular measures: Modi's, Barnes', and Multidimensional Energy Poverty Index (MEPI). We then estimate a dynamic probit model, the Wooldridge Conditional Maximum Likelihood (WCML) estimator, for the probability of being energy poor, which is defined based on three measures. WCML addresses the initial conditions problem encountered in non-linear dynamic models in a robust manner and identifies the coefficient of energy poverty persistence. During the period under analysis, energy prices, in particular the price of kerosene, soared. The contributions of the paper therefore lie in investigating the impact of a rise in the price of energy on household energy use behavior and energy poverty, and in exploring the correlates of energy poverty over time.

We find strong state dependence on energy poverty in urban Ethiopia. A household that is energy poor in any given period is 10–16% more likely to be energy poor in the subsequent period. This provides evidence of the presence of an energy trap an equilibrium level of energy poverty that is difficult to exit from without external interventions. Regression results from Wooldridge's conditional maximum likelihood estimator show that increase in the price of kerosene increases energy poverty significantly. Drawing on a fractional response estimator, we augment the analysis and show that the rapid increase in the price of kerosene, which Ethiopia experienced 2004–2009, resulted in a significant decline in the ratio of clean energy used by households measured in kilogram oil equivalents. This is mainly attributed to the large increase in the quantity of charcoal consumed by households in urban Ethiopia in response to the unprecedented sharp increase in the price of kerosene.

Our findings have important policy implications. First, the fact that there is a great deal of energy poverty persistence implies that households likely lack the capacity to acquire modern and relatively costly cooking appliance and switch to clean energy sources. During the period under analysis, the price of electricity in real terms declined by half, but households did not switch to using electricity for cooking, possibly because of the high purchase price of electric cookstoves. An electric stove used for baking the staple food injera costs almost 10 times as much as an improved biomass stove in the capital, where a large majority of the households reside. This clearly points to the need for micro-finance opportunities to enable poor households to acquire costly cookstoves. This is indeed what previous studies (Alem et al., 2017; Edwards and Langpap, 2005; Lewis and Pattanayak, 2012) conclude as well. Second, the price of kerosene soared at an unprecedented level from 2004 to 2009, causing households to increase their consumption of charcoal. The use of charcoal has large adverse effects on the environment, the climate, and the health of household members. Consequently, careful policies addressing the increased use of charcoal should be implemented. Third, the rapid increase in the price of kerosene, which is mostly consumed by the poor, coupled with cheap electricity has noticeable distributional implications. More specifically, the rich, who already have the capacity to use expensive cooking appliances, benefit significantly, while the poor experience significant welfare loss. Policy makers should therefore consider alternative approaches to protect the welfare of the poor during times of energy price inflation.

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A Appendix: Trends in energy prices and consumption

Figure A.1: Average fuel prices in Addis Ababa at woreda level over time

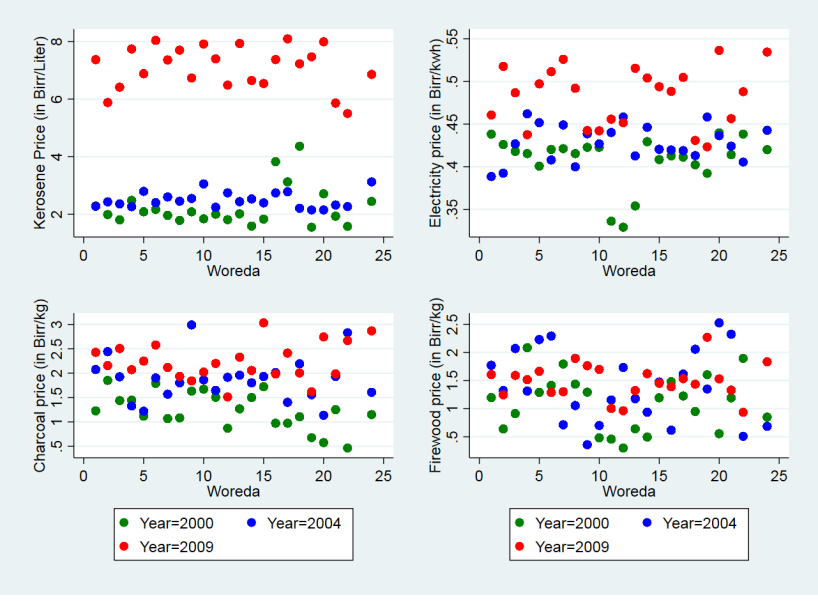


Figure A.2: Trends in median energy prices

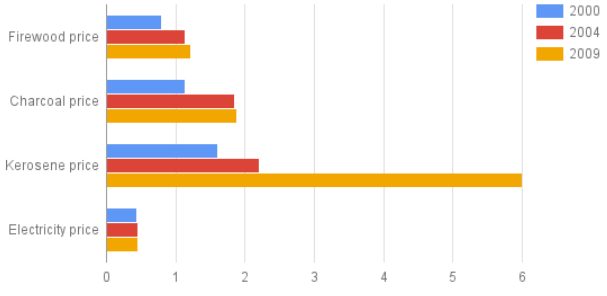
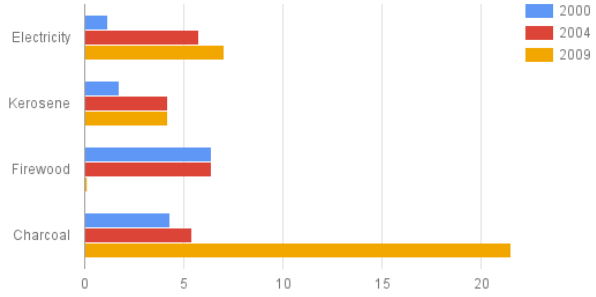


Figure A.3: Trends in median energy consumption in standard units



B Appendix: Regressions with nominal energy prices

TABLE B.1: *Descriptive statistics of nominal energy prices by year*

	[2009]		[2004]		[2000]	
	Mean	SD	Mean	SD	Mean	SD
Firewood (birr/k.g)	1.282	0.705	1.262	0.86	0.923	0.655
Charcoal (birr/k.g)	2.173	1.05	1.631	0.666	1.216	0.524
Kerosene (birr/liter)	7.685	2.777	2.784	0.894	2.335	1.091
Electricity (birr/kwh)	0.476	0.087	0.433	0.062	0.411	0.06
Observations	434		434		434	

TABLE B.2: *Correlates of Energy Poverty - Marginal Effects from Random Effects Probit Regressions*

Variables	Modi_poor	Bar_poor	MEPI_poor
	(1)	(2)	(3)
Lagged Poverty	0.088***	0.281***	0.249***
	(0.029)	(0.023)	(0.024)
Firewood log price	0.049**	0.042*	0.023
	(0.024)	(0.024)	(0.025)
Charcoal log price	-0.011	0.018	-0.034
	(0.031)	(0.033)	(0.034)
Kerosene log price	0.123***	0.181***	0.189***
	(0.045)	(0.046)	(0.047)
Electricity log price	-0.065	0.092	-0.014
	(0.071)	(0.079)	(0.080)
Head, age	-0.001	-0.003**	-0.003**
	(0.001)	(0.001)	(0.001)
Head, female	-0.048	-0.021	-0.053
	(0.031)	(0.033)	(0.034)
Head, primary school completed	-0.083**	-0.051	-0.099***
	(0.037)	(0.033)	(0.034)
Head, secondary or junior sec. school completed	-0.162***	-0.165***	-0.204***
	(0.043)	(0.040)	(0.041)
Head, tertiary school completed	-0.271***	-0.205***	-0.251***
	(0.068)	(0.053)	(0.054)
Head, employer and own account-worker	0.037	0.019	-0.025
	(0.032)	(0.035)	(0.036)
Head, civil or public servant	0.046	0.022	-0.008
	(0.035)	(0.048)	(0.048)
Head, private sector employee	0.040	0.073	-0.008
	(0.042)	(0.053)	(0.053)
Head, casual worker	0.142***	0.095	-0.021
	(0.044)	(0.059)	(0.058)
Proportion of females	-0.001	-0.015	-0.051
	(0.061)	(0.067)	(0.070)
Number of children members	0.045***	-0.032**	-0.025*
	(0.013)	(0.013)	(0.013)
Number of elderly members	0.024	0.085	-0.009
	(0.051)	(0.059)	(0.068)
Log of Real Consumption per aeu	-0.201***	-0.129***	-0.099***
	(0.019)	(0.022)	(0.022)
Round Fixed Effects	Yes	Yes	Yes
City Fixed Effects	Yes	Yes	Yes
Observations	868	868	868

Notes: Columns [1], [2] & [3] of this table presents marginal effects from random effects probit estimators for the correlates of energy poverty measured by the three indicators (Modi's, Barnes' and Multidimensional Poverty Index (MPI)) respectively with nominal energy prices. Standard errors in parentheses. ***, ** and * denote significance at the 1, 5 and 10% levels, respectively.

TABLE B.3: *Correlates of Energy Poverty - Marginal Effects from WCML Estimator*

Variables	Modi_poor	Bar_poor	MEPI_poor
	(1)	(2)	(3)
Lagged Poverty	0.040	0.168**	0.098***
	(0.035)	(0.080)	(0.037)
Initial Poverty status(2000)	0.092**	0.144**	0.210***
	(0.037)	(0.070)	(0.037)
Firewood log nominal price	0.051**	0.042*	0.029
	(0.024)	(0.024)	(0.025)
Charcoal log nominal price	-0.010	0.017	-0.036
	(0.030)	(0.034)	(0.034)
Kerosene log nominal price	0.119***	0.180***	0.175***
	(0.044)	(0.047)	(0.046)
Electricity log nominal price	-0.053	0.108	-0.029
	(0.071)	(0.079)	(0.078)
Head, Age	-0.001	-0.003**	-0.003**
	(0.001)	(0.001)	(0.001)
Head, Female	-0.047	-0.023	-0.061*
	(0.031)	(0.034)	(0.033)
Head, primary school completed	-0.081**	-0.039	-0.081**
	(0.037)	(0.034)	(0.034)
Head, secondary or junior secondary school completed	-0.163***	-0.158***	-0.183***
	(0.043)	(0.041)	(0.042)
Head, tertiary school Completed	-0.269***	-0.196***	-0.212***
	(0.068)	(0.055)	(0.058)
Head, employer and own account-worker	0.037	0.016	-0.024
	(0.032)	(0.036)	(0.035)
Head, Civil or public servant	0.048	0.025	-0.030
	(0.035)	(0.048)	(0.047)
Head, Private sector employee	0.039	0.078	-0.023
	(0.042)	(0.053)	(0.051)
Head, Casual worker	0.143***	0.090	-0.010
	(0.044)	(0.059)	(0.057)
Proportion of females	-0.007	-0.019	-0.038
	(0.061)	(0.068)	(0.068)
Number of Children members	0.046***	-0.035***	-0.023*
	(0.013)	(0.013)	(0.013)
Number of elderly members	0.026	0.087	-0.015
	(0.051)	(0.060)	(0.067)
Log of Real Consumption per aeu	-0.197***	-0.123***	-0.091***
	(0.019)	(0.022)	(0.021)
Round Fixed Effects	Yes	Yes	Yes
City Fixed Effects	Yes	Yes	Yes
Observations	868	868	868

Notes: Columns [1], [2], & [3] of this table present marginal effects from random effects probit estimators for the correlates of energy poverty measured by the three indicators (Modi's, Barnes' and Multidimensional Energy Poverty Index (MEPI), respectively, with nominal energy prices. Standard errors in parentheses. ***, **, and * denote significance at the 1, 5, and 10% levels, respectively.

TABLE B.4: *Energy prices and household energy use: Results from a Fractional Response Estimator*

Variables	OLS	GLM Marginal effects
	(1)	(2)
Firewood log nominal price	0.084***	0.064**
	(0.030)	(0.030)
Charcoal log nominal price	0.194***	0.196***
	(0.040)	(0.039)
Kerosene log nominal price	-0.226***	-0.203***
	(0.040)	(0.039)
Electricity log nominal price	-0.277	-0.346*
	(0.220)	(0.204)
Head, Age	-0.001	-0.001
	(0.001)	(0.001)
Head, Female	-0.029	-0.036*
	(0.020)	(0.021)
Head, primary school completed	0.037	0.025
	(0.023)	(0.024)
Head, secondary or junior secondary school completed	0.060**	0.041*
	(0.024)	(0.024)
Head, tertiary school Completed	0.140***	0.110***
	(0.035)	(0.036)
Head, employer and own account-worker	-0.042*	-0.048**
	(0.022)	(0.022)
Head, Civil or public servant	0.013	0.015
	(0.027)	(0.030)
Head, Private sector employee	-0.039	-0.043
	(0.030)	(0.031)
Head, Casual worker	-0.073**	-0.069*
	(0.034)	(0.036)
Proportion of females	0.106**	0.086*
	(0.046)	(0.047)
Number of Children members	-0.004	-0.006
	(0.007)	(0.008)
Number of elderly members	0.015	0.007
	(0.034)	(0.030)
Log of Real Consumption per aeu	0.051***	0.035***
	(0.013)	(0.013)
Round Fixed Effects	Yes	Yes
City Fixed Effects	Yes	Yes
Observations	1,302	1,302

Notes: Columns [1] & [2] of this table presents regression results from a fractional response estimator on the correlates of the proportion of energy in kilogram oil equivalent units obtained from clean energy sources with nominal energy prices. Robust standard errors in parentheses. ***, ** and * denote significance at the 1, 5 and 10% levels, respectively.

Cost of Power Outages for Manufacturing Firms in Ethiopia: A Stated Preference Study*

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Abstract

Having a reliable supply of electricity is essential for the operation of any firm. In most developing countries, however, electricity supply is highly unreliable. In this study, we estimate the cost of power outages for micro-, small-, and medium-sized enterprises in Addis Ababa, Ethiopia, using a stated preference survey. We find that the willingness to pay, and thus the cost of power outages, is substantial. The estimated willingness to pay for a reduction of one power outage corresponds to a tariff increase of 16 percent. The willingness to pay for reducing the average length of a power outage by one hour corresponds to a 33 percent increase. The compensating variation for a zero-outage situation corresponds to about three times the current electricity cost. There is, however, considerable heterogeneity in costs across sectors, firm sizes, and levels of electricity consumption. Policy makers could consider this observed heterogeneity when it comes to aspects such as where to invest to improve reliability and different types of electricity contracts.

JEL Codes: D22, Q41

Keywords: power outages, willingness to pay, choice experiment, Ethiopia.

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1 Introduction

The literature has documented abundant evidence of the indispensable importance of access to a reliable supply of electricity for economic growth (Andersen and Dalgaard, 2013; Dinkelman, 2011; Lipscomb et al., 2013). However, a sufficient and reliable supply of electricity is far from a reality in developing countries, and this is especially a problem in sub-Saharan Africa. Frequent and lengthy outages characterize the electricity supply in this part of the world. Energy utilities in sub-Saharan African countries are mainly publicly owned and usually opt to keep tariffs at a very low level to appease their urban constituency. The existing low electricity tariff rates make the costly investments required to improve supply economically unviable (Collier and Venables, 2012). While it is in customers' interest to pay low electricity tariffs, the question remains whether they would be willing to pay more for improvements in electricity service, particularly improvements in the reliability of supply.

The objective of this paper is to measure the willingness to pay for improved reliability of electricity supply among one important group of customers in developing countries: micro-, small-, and medium-sized manufacturing enterprises in the capital of Ethiopia, Addis Ababa. We do this by using a stated preference method, and we focus on two broad aspects of power outages: the number of outages experienced in a month and the average length of a typical outage. In this study, we focus on firms in general and micro-, small-, and medium-sized manufacturing enterprises in particular, as these are economic agents that play a critical role in facilitating growth and creating employment opportunities in developing countries. Moreover, although the industry sector and residential consumers each account for 38% of electricity consumption in the country, the share of firms' consumption is expected to outstrip the share of consumption by households, making firms a point of interest.

Lack of reliable electricity service has been listed as a major obstacle preventing growth of firms in developing countries. In the 2017 World Bank Enterprise Survey (WBES), about 40% of firms in sub-Saharan Africa stated that a shortage of electricity was a major constraint to the operations of the firm (WBES, 2017).[1] The same survey also found that the average firm in sub-Saharan Africa lost about 49 hours of economic activity in a typical month as a result of outages in 2015. Among Ethiopian firms, an average firm lost about 47 hours of economic activity per month as result of outages in the same period. The estimated incurred loss in terms of annual sales was about 7% for an average Ethiopian firm, while the 2017 WBES shows that the figure was about 8.2% for an average sub-Saharan African firm. Allcott et al. (2016) report that electricity shortages reduced average output by about 5% for Indian manufacturing firms. However, the effect on productivity was small because of the possibility of storing most inputs during outages. Fisher-Vanden et al. (2015) find that an increase in electricity shortages has increased the unit cost of production of Chinese firms by about 8%.

To mitigate the negative impacts of power outages, firms have employed different strategies in developing countries, such as more flexible production and improved storage capacity. One obvious strategy is to invest in backup means of producing electricity, such as diesel generators. Backup diesel generators are costly and it has been estimated that in sub-Saharan Africa, self-generated electricity costs three to ten times as much as the electricity purchased from the grid (Eifert et al., 2008; Foster and Steinbuks, 2009). Even if a firm uses a generator, it would still face output loss, since substantial time and costs are associated with restarting machines after an outage, and the self-generated power might not be sufficient to run production at full capacity (Beenstock, 1991). Diesel generators also have negative impacts on air quality and noise levels. Moreover, a backup genera-

[1]The figure for firms in South Asia was around 46% for the same period.

tor requires a large upfront investment cost at the time of purchase, since borrowing money for this type of investment is difficult, if not impossible, in most sub-Saharan African countries. Thus, investment in a backup generator is most likely suboptimal, as it uses funds that could have been allocated to increasing production capacity (Reinikka and Svensson, 2002).

Long-term and sustainable solutions to improve the reliability of electricity supply in a country include investment in generation and distribution capacity together with a more flexible price-setting scheme, such as peak-load pricing. In fact, one of the main reasons for the acute shortage of generation capacity in Africa is underpricing (Collier and Venables, 2012). Strategies for long-term reliability of electricity supply are particularly important in developing countries, where power outages are frequent events and there is a steady increase in demand. Large infrastructure programs, such as improving and modernizing the grid, require large investment costs, and this is typically out of reach for most utilities in sub-Saharan Africa. One way to finance investments incrementally is through an increase in the electricity tariff. Implementing an increase in tariffs to finance investments is not easy, since the increase is done before investments are made. Thus, it is necessary to understand customers' willingness to pay for such improvements.

This paper investigates micro-, small-, and medium-sized manufacturing enterprises' willingness to pay for improvements in the reliability of electricity supply. Since our focus is on the value of improvements that bring reliability to levels that do not exist today, we employ a stated preference method: choice experiment. Most of the research to date has used a revealed preference approach, where an indirect inference is made about the cost from actual averting expenditures of the firms, such as spending on backup generators. However, in many developing countries, firms' expenditures on equipment to cope with outages, such as backup generators, might be limited because of the

credit market imperfection, raising the need to complement revealed preference approaches with stated preference methods.

Stated preference methods have primarily been used to measure the willingness among households to pay for improvements in the reliability of electricity supply (e.g., Abeberese, 2017; Carlsson and Martinsson, 2007; Meles, 2017; Moeltner and Layton, 2002; Oseni, 2017). Two studies that come close to the current study on enterprises are those of Morrison and Nalder (2009) and Ghosh et al. (2017). Morrison and Nalder (2009) analyze attitudes toward power among service and manufacturing businesses in Australia. However, the problems related to power outages there differ substantially from a developing country context, and the study focuses on a reduction of four outages per year, which corresponds to the total number of outages during a year. Ghosh et al. (2017) use a contingent valuation study to examine the willingness of micro and small enterprises in India to pay to reduce power outages. In contrast, our study focuses on enterprises' valuation of a reliable electricity supply in sub-Saharan Africa, which is an area prone to substantial problems with a reliable supply of electricity, and we shed light on two key attributes of power outages: frequency and duration.

Our results show that frequent and lengthy outages are causing substantial economic damages to small manufacturing firms in Ethiopia. In particular, we find that the total cost of outages for an average firm in our sample is about three times its current monthly electricity tariff. On the other hand, we also find that there is heterogeneity in the cost of outages, depending on the size, location, and sector of the firm.

2 The Survey and the Econometric Model

2.1 The Choice Experiment

Both the contingent valuation method (e.g., Carlsson and Martinsson, 2007; Moeltner and Layton, 2002) and choice experiments (e.g., Carlsson and Martinsson, 2008; Ozbafli and Jenkins, 2016) are stated preference methods used to investigate the willingness to pay for improvements in the reliability of electricity supply. In this study, we use a choice experiment, since the objective is to investigate the marginal willingness to pay for changes in the two main characteristics related to power outages: duration and frequency.

The choice experiment was part of a large survey carried out with micro-, small-, and medium-sized manufacturing enterprises in Addis Ababa, Ethiopia, and the overall objective of the study was to investigate the energy transition and challenges faced by these enterprises. The survey was carried out in collaboration with the Environment and Climate Research Center (ECRC) at the Ethiopian Development Research Institute (EDRI), and the respondents were owners or managers of micro-, small-, and medium-sized enterprises. The questionnaire consisted of three parts: (i) general information about the firm, (ii) detailed questions related to the firm, and (iii) the choice experiment. The final questionnaire was the result of several focus group studies followed by three pilot studies with 223 firms.[2]

We sampled micro-, small-, and medium-sized manufacturing enterprises located in Addis Ababa in two stages. First, we randomly chose 1,000 of these enterprises from a list of more than 20,000 registered firms obtained from the Addis Ababa Trade Bureau and the Central Statistical Agency. Then, we chose owners or managers of these enter-

[2]In addition, we conducted a trust experiment with 260 randomly selected survey participants.

prises to be the respondents in our study, because they are the ones who make important decisions when it comes to investments in production capacity, for which decisions on energy sources are crucial.[3]

In the introduction to the choice experiment, we first gave a general introduction to power outages and how utilities can reduce them by constructing new dams, upgrading the grid networks, improving the existing transmission and distribution lines, and improving customer service in case of technical failures. This was followed by a description of the scenario (see Appendix A). The scenario focused on the firm owner's willingness to pay to reduce power outages by considering that the Ethiopian Electric Utility could improve reliability by making investments. The main effects of these investments would be a reduction in both the frequency and duration of power outages experienced by the firm.

Each respondent was asked to choose the preferred alternative in four different choice sets. Each choice set included the status quo—that is, the current situation—and two alternatives with improvements in terms of duration or frequency of power outages. The trade-off for the owner would be a reduction in these two parameters and increased electricity prices. To facilitate understanding, we also presented an example of a choice set to the respondents after we read the scenario. The attributes and levels used in the choice experiment are presented in Table 1. The levels for the current situation (status quo) for Ethiopia were obtained from the Enterprise Survey of the World Bank for the year 2015 (WBES, 2017). In the third column of Table 1, we show the current situation during a typical month, which consists of, on average, 11 outages, each lasting 5 hours, and an electricity

[3] In a few cases where we could not reach the owner or manager, production managers and owners' spouses responded instead.

price of 0.67 Ethiopian birr (ETB)[4] per kWh.[5] The attribute levels in the fourth column present the frequency and duration of power outages after the improvements. We use a linear D-optimal procedure in Stata without any priors to generate a level-balanced design with 12 choice sets.[6] These 12 sets are then randomly blocked into three blocks with four choice sets in each.

TABLE 1: *Attributes and Levels in the Choice Experiment*

Attribute	Description	Current Situation	Levels
Frequency	Number of outages in a typical month	11	5, 7, 9, 10
Duration	Length of a typical outage in hours	5	2, 3, 4, 4.5
Cost (birr/kWh)	Cost of electricity per kWh	0.67	0.8, 0.94, 1.07, 1.21

The survey was conducted in the form of an interview since some of the respondents might be illiterate. We gave the respondents a card depicting each choice set to make it easier for them to make their choices (see Figure A.1 in Appendix A). To help the respondents better understand the cost attribute, we reminded them about their energy consumption from the last month and the equivalent monthly electricity expenditure for each alternative.

[4]Birr is the Ethiopian currency, and the exchange rate at the time of survey (April 2017) was US$1 = 23.8 ETB. An industrial worker's daily wage in Addis Ababa during the survey period was about 30–50 ETB.

[5]From the survey, we gathered information about the average frequency and duration of outages faced by micro-, small-, and medium-sized enterprises located in Addis Ababa. Our survey also includes questions about the frequency and duration of outages that each firm experienced in the past 30 days. Albeit small differences, the information provided in the choice experiment on average is close to the average experienced outage. The utilities in Ethiopia use an increasing block price strategy with seven blocks. The lowest block covers consumption levels from 0 to 50 kWh per month with a price of 0.27 birr per kWh, while the highest block includes consumption levels above 500 kWh per month with a price of 0.6943 birr per kWh. As shown in Table 1, most of the firms consume more than 500 kWh per month, motivating 0.67 birr per kWh as the average price in the current situation.

[6]We use the DCREATE command made available by Arne Risa Hole.

A frequently discussed problem with stated preference studies is that they are hypothetical in nature, and thus they are not incentive compatible. A respondent can express a strong view in one direction without facing the direct consequences of his or her choices. To reduce this problem, Cummings and Taylor (1999) developed the idea of cheap talk scripts to circumvent the pitfalls associated with the hypothetical nature of the decisions, in their case, protest answers in a contingent valuation study. The cheap talk script discusses the fact that there is a tendency for people to both over- and underestimate willingness to pay. Most stated preference surveys are concerned with overstatement of willingness to pay. However, in the case of power outages, there is also a risk that respondents might protest against the premise of the scenario, which is that they have to face higher costs in order to improve reliability (Carlsson et al., 2011).

2.2 Econometric Analysis

In our analysis, we apply a random parameter logit model that allows for explicit modeling of unobserved heterogeneity. The utility each individual q obtains from selecting alternative i in choice set t can be defined as:

$$U_{iqt} = \quad \alpha_{iqt} + \beta_{iqt} X_{iqt} + \epsilon_{iqt} \tag{1}$$

where α_{iq} is an alternative-specific constant that captures individual i's intrinsic preference for the improvements and X_{iqt} stands for a vector of attributes. The vector of β_q coefficients varies across individuals with a density function of f(β_q— θ), where θ is the true parameter of the distribution. When we assume that the unobserved error term ϵ_{iqt} is an independently and identically distributed (IID) type I extreme value, we obtain a random parameter logit (mixed logit) model. We use simulated maximum likelihood to estimate the model using 500

Halton draws. In the estimations, we use a triangular distribution for the random parameters of all attributes, with the upper endpoint set to zero and the lower endpoint set to twice the size of the mean (Hensher and Greene, 2003).[7] This restriction ensures that the cost, duration, and frequency attributes have a negative sign–that is, an increase in any of the attributes results in disutility. We have also explored a log-normal distribution as a way to restrict the sign of the coefficients, but as is commonly found in the literature, we have problems with convergence and fat tails of the distribution.

The analysis rests on the assumption that a respondent takes all the attributes and alternatives into consideration and then chooses the preferred alternative in a choice set. However, studies reveal that respondents often use heuristics when making decisions and might not even take all the attributes into consideration (Carlsson et al., 2011; Hensher et al., 2005; Scarpa et al., 2009), usually referred to as attribute non-attendance. This might arise for a number of reasons, such as unwillingness to pay for proposed improvements, less weight attached to some attributes, or simply cognitive fatigue. Whatever the reason might be, previous studies have shown that failing to account for the fact that respondents do not consider an attribute when making a decision in the estimation could result in biased estimates. There are several approaches to deal with this and here we use the responses to a follow-up question that explicitly asked individuals to indicate to what extent they have attended to each of the attributes while making their choices. The response alternatives were *Always, In some but not all, and Not at all.* For each attribute to which a respondent did not attend, we restrict the coefficient to zero for that particular attribute and respondent when estimating the model (Carlsson et al., 2010).

[7] If a normal distribution is assumed, then a subject is allowed to have both positive and negative effects on utility from an increase in any of the attributes, which is undesirable and unlikely.

From the coefficient estimates, we then estimate marginal willingness to pay for the two attributes, which is calculated as the ratio between the attribute coefficient and the price coefficient. If we view these estimates as representative of the whole sample, we make the implicit assumption that the non-attendance is due to a decision heuristic and not a proper reflection of an actual preference. In other words, those that did not attend to the cost attribute still have a preference for the cost attribute, but opted not to attend to this attribute when responding in the experiment. The best available information we have about the preference for the non-attended attributes is the preferences among those that actually did attend to the attribute. Clearly, if attendance is correlated with the strength of the preference, this is not an appropriate assumption.

3 Results

3.1 Descriptive Statistics

In Table 2, we report descriptive statistics of the firms and their owners included in our sample. We interviewed owners or managers of 1,000 firms operating in different parts of Addis Ababa, and after dropping observations with missing information on some socioeconomic aspects, we are left with a final working sample of 947 firms.

TABLE 2: *Descriptive Statistics*

Variable	Obs.	Mean	Std. dev.	Min	Max
Firm characteristics					
Firm age in years	941	6.26	5.85	1	59
Number of employees	947	9.93	10.6	1	70
Monthly sales (in 1,000 birr)	933	145	195	0	5,877
Own diesel generator (= 1 if yes)	947	0.14	0.35	0	1
Electricity consumption (kWh per month)	947	990	2,974	11	57,971
Industry zone location (= 1 if yes)	947	0.3	0.46	0	1
Monthly profit lost due to outages (in birr)	914	4,683	12,816	0	200,000
Cost due to outages (per month in birr)	934	2,807	7,314	0	100,000
Adjust operation time due to outages (= 1 if yes)	944	0.49	0.5	0	1
Owner characteristics					
Age of the owner (in years)	937	39.39	10.55	21	76
Male (= 1 if owner is male)	942	0.8	0.4	0	1
At least college diploma (= 1 if yes)	947	0.14	0.34	0	1
Business experience in years	936	7.82	6.84	1	59
Trust in electric utility (0 if low and 10 if high)	947	4.89	2.53	0	10

An average firm in our sample has been in operation for little more than six years and has 10 employees. The average monthly revenue is 145,000 birr. About 14% of firms own backup generators that are used during power outages and the average electricity consumption is 990 kWh per month. In addition, 30% of the firms are located in industry zones. These are industry clusters built and owned by the government with the purpose of supporting micro-, small-, and medium-sized manufacturing enterprises. The average age of an owner or manager of a firm is 39 years and about 80% of the owners are male. Only 14% of the owners or managers have at least a college diploma.

On average, owners and managers in our sample have business experience as an owner or manager extending to eight years. When asked to rate their trust in the electric utility on a scale ranging from 0 (no trust at all) to 10 (have complete trust), owners or managers state a rather low level of trust, with an average of less than 5. The average loss in profits due to outages is 4,683 birr and, on average, firms incur 2,807 birr as extra costs of outages on items such as fuel and

maintenance expenses of generators and labor costs. Comparing the costs incurred in terms of monthly sales, on average, firms lose 14% of their monthly sales. About 49% of the firms in our sample have been forced to adjust their operation times, and 14% of firms report owning a diesel generator that is used during power outages.

Figure 1 shows the self-reported frequency and average duration of typical outages. The average number of outages is about 13 per month. This is comparable to the frequency of outages in the status quo alternative of our choice experiment, with 11 outages. In terms of duration, an overwhelming majority of firms in our sample (75%) experience outages lasting more than 2 hours.

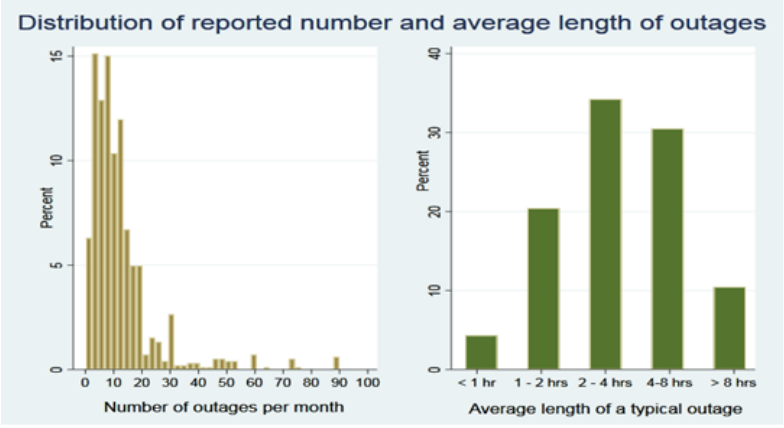

Figure 1: Distribution of Self-Reported Frequency and Duration of Outages

4 Econometric Analysis

4.1 Main Result

We begin by looking at the stated non-attendance, based on the follow-up question asking respondents to state to what extent they

had attended to each of the attributes while making their choices. Table 3 presents a summary of the distribution of attendance for each of the attributes.

TABLE 3: *Attendance to Attributes (n=947)*

Attendance	Frequency	Duration	Cost
Yes	94%	93%	65%
No	6%	7%	35%

A large majority of the respondents stated that they had attended to both the frequency and the duration attributes, but only 65% had attended to the cost attribute. While this is common in the literature Carlsson et al. (2010), it points to the importance of considering this issue in the analyses. We estimate a probit model where the dependent variable is equal to one if any of the attributes were not attended to, and otherwise zero. Results are presented in Table B.1 in Appendix B. The analysis shows that the likelihood of non-attendance is higher among larger firms if the firm has adjusted its operation times due to outages, if the firm incurs high costs of outages, and if the owner has a low level of trust in the electric utility. This is an indication of a focus on the outage attribute among firms that suffer more from outages.

Our main analysis is based on a regression model where we restrict the corresponding coefficient to zero for those respondents that stated that they did not attend to the attribute. Based on this model, we estimate marginal willingness to pay for the attributes. Our interpretation is that this is the marginal willingness to pay for the whole sample, including those that did not attend to the cost attribute. As we have discussed, the implicit assumptions are that those not attend-

ing to the cost attribute do not have zero marginal utility of money and that we use the estimate for those attending to the attribute to infer the marginal utility of money for those not attending to the cost attribute. In Table 4, we present the results of the random parameter logit model with restricted triangular distributions using observations from 947 firms.

TABLE 4: *Results of the Random Parameter Logit Model with Triangular Distribution*

	Coefficient	Coefficient std. dev.
ASC (= 1 for improved alternative)	0.04	0.717***
	(0.055)	(0.094)
Frequency	–0.774***	0.774***
	(0.035)	(0.035)
Duration	–1.570***	1.570***
	(0.071)	(0.071)
Cost	–7.153***	7.153***
	(0.383)	(0.383)
Log-likelihood	–2,842.45	
Pseudo R2	0.316	
Observations	3,788	
Subjects	947	

Note: Standard errors in parentheses. ***, **, * denote significance at 1%, 5%, and 10% levels, respectively.

As expected, all the attribute coefficients are negative and statistically significant. Moreover, all the estimated standard deviations of the coefficients are statistically significant, indicating that the model captures unobserved heterogeneity among the respondents. The alternative-specific constant (ASC) is a dummy variable for the alternatives with improvements. The fact that the ASC is not statistically significant indicates that, on average, respondents did not just choose one of

the improved alternatives or choose to stick with the current situation without considering the levels of the attributes in each of the alternatives.

Our main interest lies in estimating the marginal willingness to pay (MWTP) for the two outage attributes: frequency and duration. The marginal willingness to pay for both attributes is presented in Table 5.

TABLE 5: *MWTP Estimates in birr per kWh and per Month and Total Cost of Outages in birr per Month*

Attributes	Marginal WTP (birr per kWh)	Marginal WTP (birr per month)	Total cost of outages (birr per month)
Frequency	0.11 (0.12–0.10)	109	1,198
Duration	0.22 (0.24–0.20)	218	1,089

Note: Standard errors in parentheses estimated using the Delta method.

On average, firms are willing to pay 0.11 birr per kWh for a one-unit reduction in the number of outages they face per month. This amount corresponds to about 16% of the current price of a kWh of electricity. Regarding the duration attribute, on average, firms are willing to pay 0.22 birr per kWh to reduce the average length of an outage by one hour. Compared with the current electricity tariff, this amounts to 33% of the electricity price per kWh.[8]

We also calculate the marginal WTP in birr per month for each attribute by the average monthly electricity consumption of firms in our sample. The results from this analysis are presented in column 3. We also estimate willingness to pay as a total outage cost per month. This is done by multiplying the marginal WTP estimate for outages by the

[8] In Tables B.2 and B.3 in Appendix B, we present the corresponding estimates for a random parameter logit (RPL) model without considering stated non-attendance. These estimates are slightly higher than the estimates when considering attribute non-attendance in the estimation procedure.

total number of outages and the marginal WTP estimate for duration by the average duration, and then adding the overall preference for a change as indicated by the alternative-specific constant divided by the cost attribute. This estimate is then multiplied by the average monthly electricity consumption (990 kWh/month) so that we have a measure in birr per month. The total monthly cost of outages for an average firm is 2,293 birr (US$96). This implies a threefold increase from the firm's average current monthly electricity bill. The cost of outages amounts to 3% of the firm's monthly sales, or about 61% of the average monthly cost of using backup generators.

4.2 Observed Heterogeneity in Preferences

So far, we have focused on the sample averages. This provides only limited insight to inform policy makers on how to prioritize investments in the energy sector. It is indeed important for policy makers to know and understand heterogeneity, if there is any, in cost of outages depending on different characteristics of firms. To shed some light on this, we investigate three important aspects of firm characteristics–location, size, and type of sector–by estimating separate models for different groups of firms.

4.2.1 Location

Firms in our sample can be divided into two broad categories based on the setup of their locations: industry clusters and nonindustry clusters. Industry clusters are zones set up by the government with the aim of providing working premises and necessary infrastructure for manufacturing firms. They are also intended to facilitate technological spillovers among firms and spur innovation. From the point of view of addressing power outages, the location of firms would be one aspect that policy makers could consider when prioritizing in-

vestments. The estimated models for industry and nonindustry zone firms are presented in Table B.4 in Appendix B and the corresponding marginal willingness to pay (MWTP) estimates are presented in Table 6.

TABLE 6: *MWTP for Frequency and Duration Attributes Based on Location of Firms*

Attributes	Industry cluster	Nonindustry cluster
MWTP in birr per kWh		
Frequency	0.13 (0.11–0.15)	0.10 (0.09–0.11)
Duration	0.23 (0.20–0.27)	0.21 (0.20–0.23)
MWTP in birr per month		
Frequency	113	104
Duration	200	219

Note: Standard errors in parentheses.

As can be seen in the top panel of Table 6, firms located inside an industry cluster have, on average, higher MWTP per kWh for both attributes. The MWTP of reducing frequency of an outage by one unit is 0.13 birr for the industry cluster group, but only about 0.10 birr for the nonindustry cluster group. Using z-tests, we can reject the hypothesis of equal MWTP values between the two groups for the frequency attribute (p-values = 0.002), while we fail to reject the hypothesis for the duration attribute (p = 0.344).

Based on the estimated MWTP values and current monthly electricity use, we can estimate the MWTP per month for the two groups as well. The bottom panel of Table 6 shows that for the frequency attribute, the MWTP per month is higher for firms inside the industry cluster than for those outside the industry cluster (in the nonindustry cluster), while it is the opposite for the duration attribute. Thus, there are very small differences between the two types of firm locations from an economic point of view. It could be that firms located in industry

clusters are enjoying better electricity services and hence their cost of outages is not as large, even though these firms are different in other respects. This is true, as firms in industry clusters report suffering fewer outages per month than those in nonindustry clusters.[9]

4.2.2 Firm Size

Firm size is another aspect that might correlate with the cost of outages, and this criterion could be important for policy makers to use when planning investments. Micro firms (up to 5 employees), for example, might not have the financial resources to invest in backup generators, whereas small- (6–10 employees) and medium-sized (11–100 employees) firms are more likely to have financial resources. On the other hand, small- and medium-sized firms might rely heavily on electricity service, such that even the use of backup generators would not satisfy their needs during power outages. In this case, these groups might suffer higher costs of outages than micro firms. The estimated models for the three groups are presented in Table B.5 in Appendix B and the corresponding MWTP estimates are presented in Table 7.

TABLE 7: *MWTP Estimates by Size of Firms*

Attributes	Micro	Small	Medium
MWTP in birr per kWh			
Frequency	0.10 (0.09–0.11)	0.13 (0.11–0.15)	0.11 (0.10–0.13)
Duration	0.19 (0.17–0.21)	0.26 (0.22–0.31)	0.23 (0.20–0.26)
MWTP in birr per month			
Frequency	53	94	212
Duration	101	187	444

Note: Standard errors in parentheses.

[9]The t-test for mean comparison of frequency of outages shows that firms in industry clusters face 1.5 fewer outages than those in nonindustry clusters, and the difference is statistically significant at the 1% level. Similarly, mean ownership of generators is 16% among firms in nonindustry zones, whereas it is just 8% among those inside industry zones, and the difference is statistically significant at the 1% level.

The top panel of Table 7 shows that small firms have the highest MWTP in birr per kWh for both attributes, while micro firms have the lowest MWTP for both attributes. We tested the differences using t-statistics. For the duration attribute, the MWTP differences are statistically significant at least at the 5% level, with the exception of the comparison between small- and medium-sized enterprises where the difference is not statistically significant. The differences in MWTP for the frequency attribute are statistically significant at the 5% level only between micro- and small-sized enterprises.

The bottom panel of Table 7 shows an estimate of the MWTP in birr per month for each firm size group. As these values are obtained by multiplying the MWTP in birr per kWh by the monthly average electricity consumption of each group, we observe a different pattern when we compare across the groups. The micro firms have the lowest MWTP in birr per month for both attributes compared with the other two groups. On the other hand, the medium-sized firms have the highest MWTP in birr per month for both attributes. These differences in the average electricity consumption across the groups are the main driving force behind the observed pattern in the MWTP in birr per month figures. Thus, the outage costs are considerably higher the larger the firm is.

4.2.3 Sector

The production process and the reliance on electricity might be different in different sectors, which, in turn, could affect the outage costs. Therefore, we divide our sample into five sectors based on definitions from the Central Statistical Agency of Ethiopia: food and beverage; textile, garment, and leather; metalworking workshop; nonmetallic minerals and construction; and plastic, rubber, and machinery. Results of the random parameter logit models are presented in Table B.6 in Appendix B, and the MWTP values are presented in Table 8.

TABLE 8: *MWTP for the Attributes by Sector Measured in birr per kWh (95% confidence interval)*

	MWTP in birr per kWh		MWTP in birr per month	
	Frequency	Duration	Frequency	Duration
Food and beverage	0.08	0.17	200	425
	(0.10–0.07)	(0.19–0.14)		
Textile, garment, and leather	0.11	0.21	38	72
	(0.13–0.09)	(0.25–0.17)		
Metal-working workshop	0.11	0.24	59	129
	(0.12–0.10)	(0.28–0.21)		
Nonmetallic minerals and	0.14	0.26	114	212
construction	(0.17–0.10)	(0.32–0.20)		
Plastic, rubber, and machinery	0.12	0.22	129	237
	(0.14–0.10)	(0.26–0.19)		

As we have done above, here, in Table 8, we also estimate both the MWTP in birr per kWh and the MWTP in birr per month for each of the sectors. Column 2 shows that firms in the nonmetallic minerals and construction sector have the highest MWTP per kWh for both the frequency and duration attributes. Their MWTP per kWh corresponds to a 20% and 38% increase in the electricity price to reduce the average number of outages from 11 to 10 in a month and to reduce the average duration of an outage from 5 to 4 hours. Firms in the food and beverage sector have the lowest MWTP per kWh for improved electricity service.

In column 3 of Table 8, we show the MWTP in birr per month for each of the sectors, where we multiply the MWTP per kWh values in column 2 by the average monthly electricity consumption of the sectors. The results show that the food and beverage sector has the highest MWTP in birr per month for both attributes. The textile, garment, and leather sector is found to have the lowest MWTP in birr per month for both the frequency and duration attributes.

5 Conclusions

Access to a reliable supply of electricity is considered an important component of economic development. In many developing countries, firms are suffering from power outages that are both frequent and of long duration, which makes it difficult to plan and undertake production activities. Thus, understanding the cost associated with an unreliable electricity supply for firms is important especially for policy makers who plan investment in the energy sector.

Previous studies have used different approaches to estimate the cost of outages for firms as well as to investigate which coping mechanisms firms employ. Most of the research to date has used a revealed preference approach. However, in many developing countries, firms' expenditures on equipment to cope with outages, such as backup generators, might be limited because of the credit market imperfection, raising the need to complement revealed preference approaches with stated preference methods. To date, only a handful of studies have used a stated preference approach. These include Morrison and Nalder (2009)and Ghosh et al. (2017), who attempted to estimate the cost of outages in Australia and India, respectively. A detailed and comprehensive analysis of the issue is lacking for sub-Saharan Africa, where unreliable electricity service is among the major reasons preventing economic growth.

This paper contributes to this issue by estimating the cost of outages for micro-, small-, and medium-sized manufacturing enterprises located in Addis Ababa, Ethiopia. To this end, we conducted a choice experiment and estimated a random parameter logit model.

The proposed improvement of the service applied in our choice experiment included two different components: the average number of outages experienced in a month and the average length of a typical outage. We find that manufacturing firms in Addis Ababa incur substantial costs due to power outages. An average firm's total cost of outages is 2,293 birr(US$96) per month, which corresponds to a threefold increase from the firm's average current monthly electricity bill. The cost of outages also amounts to 3% of the firm's monthly sales, which equates to about 61% of the average monthly cost from using backup generators. Our results indicate the existence of significant heterogeneity in terms of the size, location (whether the firm is inside an industry cluster), and sector in which the firm operates. These findings have important policy implications. Given the significant cost of outages and the firms' willingness to pay to avoid outages, increasing tariff rates is one potential avenue to achieve the financial investment necessary to provide reliable electricity. In addition, the observed heterogeneity affords the opportunity to prioritize the investment in some respects, such as by considering location and focusing on industry clusters.

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Appendix

A Choice Experiment Scenario

Following is the description of the scenario that we presented to respondents in our choice experiment:

Now I will ask you questions about your company's willingness to pay to reduce power outages. As you might know, there are discussions about improving electricity service in the country by making necessary investments. The Ethiopian Electric Utility is considering investments such as the construction of new dams, upgrading of the grid networks, improving the existing transmission and distribution lines, and also improving customer service in case of technical failures. It is believed that these investments will reduce both the frequency and duration of unplanned power outages observed during your operation hours. These investments are costly and would result in increased electricity prices.

In order to obtain information about what customers think about outages, we are going to ask you a number of questions. In particular, we will ask you to make choices among different alternatives. Each alternative will describe the frequency and average length of outages in a typical month and the cost of electricity in birr per kWh. Let me show you an example. [Show example choice card.]

	Alternative A (no action)	**Alternative B**	**Alternative C**
Frequency	11 outages	11 outages	10 outages
Length	5 hours	4.5 hours	5 hours
Cost (in birr/kWh)	0.67	0.8	0.94
Reminder: your energy use (kWh)	……..		
Your choice			

Alternative A describes the situation if no action is taken. If no improvements are made, then it is predicted that on average, you will face 11 power outages per month, with an average length of 5 hours each. Cost of electricity will be the same as today.

In alternatives B and C, investments are made to affect power outages, and this also means that the cost of electricity increases. To help you to understand what the cost increase implies, we also remind you of your current electricity use.

In alternative B, there is no change in the number of outages, but the average length of each outage is reduced to 4.5 hours. At the same time, the electricity price increases to 0.80 birr per kilowatt-hour. In alternative C, there is instead a reduction in the number of outages to 10 per month, while the average length of an outage is the same as the current situation. The electricity price increases to 0.94 birr per kilowatt-hour.

We would like to know which of these alternatives you prefer. We will ask you to make four such choices. Please bear in mind that the choice you make only affects the frequency and length of the power outages and the electricity tariff; everything else remains as it is today. The government is committed to ensure that the money obtained from the tariff increments is used solely to improve the electricity service.

Experience from previous studies indicates that people often state their unwillingness to pay to improve the current state not because they do not want improvements, but for other reasons. We believe that this can sometimes be because of a belief that they have a right to uninterrupted electricity or that the resources would not be used for their intended purpose. However, we ask that you not think this way when choosing among the alternatives. You might have other reasons to respond this way. If you have any thoughts about this, please state the reasons following your choices.

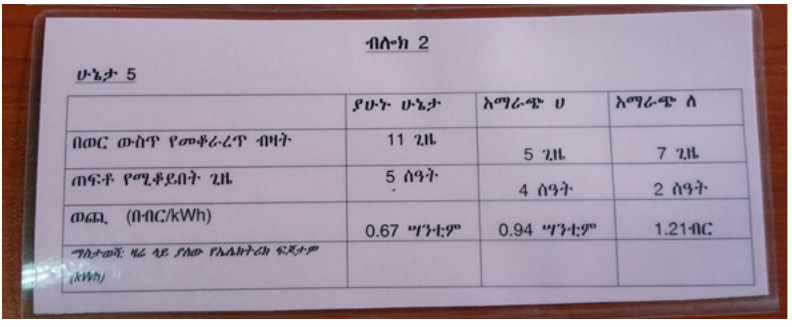

Figure A.1: Example of Choice Card Shown to Respondents

B Supplementary Regressions

TABLE B.1: *Marginal Effects of Probit Regression of Non-attendance to Attributes, Dependent Variable Equal to 1 if Attribute was Not Attended to*

Variables	
Frequency of outages (1,000)	–0.075
	(0.03)
1 = adjust operation time	0.134
	(1.53)
Cost of outages (in 100,000 birr)	0.473
	(0.69)
Satisfaction with current service	–0.103
	(2.33)**
Monthly electricity use (in 100,000 kWh)	–1.969
	(1.16)
1 = located inside industry cluster	–0.076
	(0.79)
Firm age (in years)	–0.006
	(0.76)
Number of employees (100)	0.945
	(1.84)*
Monthly sales (in 1,000,000 birr)	–0.007
	(0.05)
1 = own backup generator	–0.104
	(0.8)
Owner's age	–0.007
	(1.52)
1 = at least college diploma	0.134
	(1.02)
1 = male	0.239
	(2.13)**
Pseudo R2	0.021
N	895

Note: Dependent: = 1 if individual did not attend to one of the attributes. ***, **, * denote significance at 1%, 5%, and 10% levels, respectively.

TABLE B.2: ***RPL Model for Electricity Reliability Attributes without Consideration of Non-attendance***

	Coefficient	Std. dev.
ASC (= 1 if the new alternative is chosen)	0.063	0.709***
	-0.054	-0.091
Frequency	–0.753***	0.753***
	-0.037	-0.037
Duration	–1.572***	1.572***
	-0.078	-0.078
Cost	–5.692***	5.692***
	-0.344	-0.344
Log-likelihood	–3,118.00	
Pseudo R2	0.251	
Observations	3,788	
Subjects	947	

Note:Standard errors in parentheses. ***, **, * denote significance at 1%, 5%, and 10% levels, respectively.

TABLE B.3: ***MWTP Estimates from RPL Model without Consideration of Non-attendance (95% confidence interval)***

Attributes	RPL (triangular dist.)	Total cost of outages (ETB/month)
Frequency	0.13 (0.14–0.12)	129
Duration	0.28 (0.28–0.26)	277

TABLE B.4: ***Random Parameter Logit Model for Different Firm Locations***

Variable	Inside industry zone		Outside industry zone	
	Coefficient	Std. dev.	Coefficient	Std. dev.
ASC	0.135	0.865***	0.007	0.617***
	(0.106)	(0.163)	(0.063)	(0.120)
Frequency	–0.822***	0.822***	–0.741***	–0.741***
	(0..069)	(0.069)	(0.041)	(0.041)
Duration	–1.446***	1.446***	–1.610***	–1.610***
	(0.122)	(0.122)	(0.086)	(0.086)
Cost	–6.195***	6.195***	–7.497***	–7.497***
	(0.653)	(0.653)	(0.465)	(0.465)
Log-likelihood	–821.738		–2,012.696	
Pseudo R2	0.33		0.31	
Observations	1,124		2,664	
Subjects	281		666	

Note:Standard errors in parentheses. ***, **, * denote significance at 1%, 5%, and 10% levels, respectively.

TABLE B.5: *Random Parameter Logit Model for Different Firm Sizes*

	Micro		Small		Medium	
	Coefficient	Std. dev.	Coefficient	Std. dev.	Coefficient	Std. dev.
ASC	–0.013	0.622	–0.093	0.674	0.232**	0.811***
	(0.076)	(0.138)	(0.113)	(0.193)	(0.109)	(0.180)
Frequency	–0.706***	0.706***	–0.830***	0.830***	–0.841***	0.841***
	(0.046)	(0.046)	(0.082)	(0.082)	(0.073)	(0.073)
Duration	–1.386***	1.386***	–1.704***	1.704***	–1.724***	1.724***
	(0.092)	(0.092)	(0.158)	(0.158)	(0.141)	(0.141)
Cost	–7.1842***	7.1842***	–6.484***	6.484***	–7.418***	7.418***
	(0.531)	(0.531)	(0.801)	(0.801)	(0.750)	(0.750)
Log-likelihood	–1383.365		–663.413		–780.223	
Pseudo R2	0.27		0.35		0.37	
Observations	1,736		932		1,12	
Subjects	434		233		280	

TABLE B.6: *Random Parameter Logit Model for Different Sectors*

Variable	Food		Textile		Metal		Nonmetal		Plastic	
	Coefficient	Std. dev.	Coefficient	Std. dev.	Coefficient	Std. dev.	Coefficient	Std. dev.	Coefficient	Std. dev.
ASC	–0.019	0.709***	–0.088	0.642	0.077	0.721***	0.071	0.537	0.113	0.853***
	(0.130)	(0.224)	(0.119)	(0.207)	(0.101)	(0.172)	(0.164)	(0.353)	(0.126)	(0.190)
Frequency	–0.743***	–0.743***	–0.635***	–0.635***	–0.791***	–0.791***	–1.012***	–1.012***	–0.801***	–0.801***
	(0.084)	(0.084)	(0.067)	(0.067)	(0.067)	(0.067)	(0.140)	(0.140)	(0.076)	(0.076)
Duration	–1.471***	–1.471***	–1.221***	–1.221***	–1.750***	–1.750***	–1.951***	–1.951***	–1.496***	–1.496***
	(0.168)	(0.168)	(0.132)	(0.132)	(0.141)	(0.141)	(0.263)	(0.263)	(0.146)	(0.146)
Cost	–8.909***	–8.909***	–5.760***	–5.760***	–7.189***	–7.189***	–7.466***	–7.466***	–6.671***	–6.671***
	(1.075)	(1.075)	(0.732)	(0.732)	(0.715)	(0.715)	(1.249)	(1.249)	(0.769)	(0.769)
Log-likelihood	–534.80		–534.23		–886.82		–294.46		–572.65	
Pseudo R2	0.26		0.27		0.33		0.42		0.35	
Observations	656		664		1,212		460		796	
Subjects	164		166		303		115		199	

Note:Standard errors in parentheses. ***, **, * denote significance at 1%, 5%, and 10% levels, respectively.

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