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Clean energy and household remittances in Bangladesh: Evidence from a natural experiment

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Using a natural experiment of a rainfall-driven remittances, I provide experimental measures of how remittances affect rural household's choice of cylinder gas (LPG) as a cooking fuel over other alternative fuels in southern Bangladesh. Household choice of LPG and remittances are jointly related; therefore, I use the instrumental variable probit (IV-Probit) approach. The treatment of remittances is randomly assigned to households who suffered losses due to a natural shock from the cyclone-Roanu enabling the instrument – exogenous variation in rainfall interacted with cyclone-affected migrant household's distance to the local weather stations – to identify the average treatment effect for the treatment group (cyclone-affected remittances recipient households). I find that an exogenous increase in remittances by 1,000 Taka causes the probability of using LPG to rise by 1%. In terms of percentage change, the implied elasticity shows that a 10% increase in remittances income can raise the probability of using LPG by 2%. I also find the impact of remittances is conditional on household's health expenditures. In particular, controlling for the household's health expenditures interacted with the provision for clean water and sanitary toilet in the dwelling, the marginal effects of remittances get stronger, i.e. households are more likely to use LPG as cooking fuel. These findings counter some existing case studies and views of many policy makers that economic factors are less significant in promoting cleaner energy for the household. The results of the paper are robust to potential violations of the exclusion restriction, to alternative specifications and instruments, and possible omitted variable bias.

Keywords

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CLEAN ENERGY AND HOUSEHOLD REMITTANCES IN BANGLADESH: EVIDENCE FROM A NATURAL EXPERIMENT

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Abstract: Using a natural experiment of a rainfall-driven remittances, I provide experimental measures of how remittances affect rural household's choice of cylinder gas (LPG) as a cooking fuel over other alternative fuels in southern Bangladesh. Household choice of LPG and remittances are jointly related; therefore, I use the instrumental variable probit (IV-Probit) approach. The treatment of remittances is randomly assigned to households who suffered losses due to a natural shock from the cyclone-Roanu enabling the instrument – exogenous variation in rainfall interacted with cyclone-affected migrant household's distance to the local weather stations – to identify the average treatment effect for the treatment group (cyclone-affected remittances recipient households). I find that an exogenous increase in remittances by 1,000 Taka causes the probability of using LPG to rise by 1%. In terms of percentage change, the implied elasticity shows that a 10% increase in remittances income can raise the probability of using LPG by 2%. I also find the impact of remittances is conditional on household's health expenditures. In particular, controlling for the household's health expenditures interacted with the provision for clean water and sanitary toilet in the dwelling, the marginal effects of remittances get stronger, i.e. households are more likely to use LPG as cooking fuel. These findings counter some existing case studies and views of many policy makers that economic factors are less significant in promoting cleaner energy for the household. The results of the paper are robust to potential violations of the exclusion restriction, to alternative specifications and instruments, and possible omitted variable bias.

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CLEAN ENERGY AND HOUSEHOLD REMITTANCES IN BANGLADESH: EVIDENCE FROM A NATURAL EXPERIMENT

1. Introduction

Two facts motivate this paper. First, life in rural areas of developing countries is prone to several health risks, such as noncommunicable diseases or mortality of household members, especially women and children, attributable to indoor air pollution from inefficient cooking practices using solid fuels[1]. An estimated 41 percent of households worldwide depended on solid fuel for cooking (Bonjour, Adair-Rohani, Wolf, et al, 2013). Second, international migration and remittances flows have become a substantial global phenomenon. There are now an estimated 258 million people living in a country other than their country of birth — an increase of 49% since 2000 and a 3.4% of the world's inhabitants today are international migrants. Household incomes have experienced a steady rise achieved in part through the tremendous growth in remittances that these migrants send to origin countries[2]. According to the World Bank, remittances to low- and middle-income countries reached a record high of US$529 billion in 2018, an increase of 9.6 percent over the previous year[3]. Understanding the various functions that these remittances serve for the recipient households are a challenging but necessary task to gauge a clear portrait of its consequences in terms of the benefits and costs to the origin country.

What connection, if any, is there between the pervasive health risk due to indoor pollution in developing countries and international remittance flow? In particular, do remittances from overseas migrants play a role in reducing household exposition to indoor air pollution by promoting the use of cleaner fuel sources? The paper examines a mechanism for isolating a driver for household's energy

[1] https://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health

[2] According to the World Bank estimates officially recorded remittances to developing countries will increase by roughly 11 percent to reach $528 billion (USD) in 2018. (https://www.worldbank.org/en/news/press-release/2018/12/08/accelerated-remittances-growth-to-low-and-middle-income-countries-in-2018)

[3] https://www.worldbank.org/en/news/press-release/2019/04/08/record-high-remittances-sent-globally-in-2018

selection for clean fuel on which previous studies have not focused: remittances from family members working overseas. The paper's originality therefore comes from connecting two distinct literatures: remittances and energy. Understandably, remittances depend on many factors that also matter for clean energy choice. To address this endogeneity, the identification strategy uses a natural experiment armed with a plausibly exogenous variation in rainfall driven instrument for the *level* of remittances received. In households with members who are overseas migrants, the paper finds international remittances augments the probability of using cleaner fuel sources.

Anecdotal evidences suggest that remittances recipients may tend to use better and cleaner energy. At international level, it is commonly posited that migration can contribute to improving access to affordable modern energy services through higher incomes for migrants and the sending of remittances (Scott et al., 2018)[4]. It is also reported that remittances finance is used for various types of clean energy technologies in developing countries (Mendelson, 2013) [5]. For example, in Haiti, a pilot scheme implemented by ArcFinance to target remittances from Haitian diaspora to finance clean energy for the country's marginalised and energy poor households was successful in displacing dirtier fuels[6]. In Ecuador, a clean-energy technology programme deployed to increase rural energy access has been linked to a financial remittance mechanism (IFAD, 2009)[7]. EcoBazar carried out a project that marketed solar water heaters to Bolivian diaspora in Spain and sold them to recipients in Bolivia using a mechanism through remittances finance (NDF et al., 2015)[8]. While suggestive, these accounts do not constitute robust evidence of a causal link between remittances and clean energy usage.

[4] Scott, Andrew; Worrall, Leah and Pickard, Sam (2018) Energy, migration and the 2030 Agenda for Sustainable Development, Overseas Development Institute (https://www.odi.org/sites/odi.org.uk/files/resource-documents/12301.pdf)

[5] Mendelson, S. (2013) 'Sustainable energy access for the poor.' Americas Quarterly Online (www.americasquarterly.org/ content/sustainable-energy-access-poor).

[6] http://arcfinance.org/pdfs/pubs/Arc%20Finance_Case%20Study_Sogexpress_2013.pdf

[7] IFAD – International Fund for Agricultural Development (2009) Remittances: sending money home. Rome: IFAD

[8] NDF – Nordic Development Fund, Nordic Climate Facility and NEFCO (2015) Financing sustainable energy through remittances flows to Bolivia. NDF and NEFCO, Bolivia

This paper uses a natural experiment to demonstrate that remittances increase the probability of using cleaner energy for cooking among rural households in Bangladesh – a developing country highly vulnerable due to climate change (GCRI, 2019)[9]. The natural experiment uses plausibly exogenous variation in rainfall interacted with cyclone-affected migrant household's distance to the local weather stations as instrument for remittances received among cyclone-hit remittances-recipient households in Bangladesh.

The rationale behind this instrument is that rainfall is a critical factor determining the yield of rainfed crop that generates the main source of household income from agriculture in countries characterised by subtropical monsoon climate. It therefore is a good predictor of remittances which respond to the income shocks to the household (Yang and Choi, 2007).[10] The instrument also relieves major worries about endogeneity bias arising from reverse causality and measurement error. Furthermore, to circumvent the problem of non-random selection of migrant household from the general population, the paper harnesses a natural shock triggered off by the cyclone-Roanu that allows for a random assignment of the treatment of remittances. [11] Therefore, a key distinguishable facet of this paper is it provides an experimental measure with respect to the impact of remittances that minimises the problem of omitted variables bedevilling cross-sectional research. Using liquefied petroleum gas (LPG)[12] or cylinder gas, to represent clean cooking fuel, the instrumental variable (IV) results demonstrate that remittances significantly increase the recipient household's probability of using LPG for cooking fuel, particularly those with better indicators on health and sanitation factors.

[9] Global Climate Risk Index (GCRI) (2019) Who suffers Most from Extreme Weather Events? Weather-related Loss Events in 2017 and 1998 to 2017, Bonn: Germanwatch e.V.

[10] The instrumentation strategy is similar to Yang and Choi (2007) but with a key difference: Yang and Choi (2007) use rainfall to instrument for income shock, I use rainfall to instrument for remittances.

[11] The Cyclone Roanu made its landfall on 21 May 2016 in southern coastal regions of Bangladesh (survey area) and the data for this project was collected during October-November 2016. The random assignment of treatment is achieved through multiplying the instrument with an indicator variable equal to one if the remittances-recipient household suffered losses due to the cyclone-Roanu and zero otherwise.

[12]Increasing household use of LPG is one of several pathways to meet the goal of universal access to clean cooking and heating solutions by 2030, as stated in the United Nations' Sustainable Energy for All Initiative.

The mechanism through which remittances foster the use of clean energy for cooking purposes is not obvious. It depends both on the household's demand for clean energy and to the extent remittances create heath awareness among the members of the households. In theory, there are two underlining conditions for income growth to shift households towards better cleaner fuel sources (Hanna and Olivia, 2015). First, dirty fuels are necessarily inferior good so that the substitution effect towards cleaner fuel can dominate over the wealth effect as a result of the improved well-being of the household and second, households are sufficiently aware of the harmful effect of using dirty fuel on their health to allow for a further reinforcement to the substitution effect. In general, the source of increase in household income should be unrelated to the extent of the substitution effect. But in some cases, the increase in household income through some particularly important sources, such as remittances from overseas migrants, might affect and bolster the substitution effect. It is because remittances spending is often targeted towards those priority sectors that is reasonably capable to create added health awareness among the household members. For instance, scholars find that remittances often finance households investments in health and education (see; Adams, 2005 and 1998; Edwards and Ureta, 2003; Yang, 2005 and Alderman, 1996) as a result of which a migrant household accumulate more physical and human capital that enable them to become more productive (Taylor and Lopez-Feldman, 2009). Therefore it is reasonable that to protect their productive capacities the remittances recipient households will be more aware and cautious of their health capital which they will naturally seek to safeguard from the harmful effects of dirty fuels through the substituting towards better cleaner fuel sources for cooking.

Gauging the effects of remittances on using cleaner fuel source for cooking such as LPG, however, suffers from endogeneity bias due to reverse causality (households cooking with LPG also enjoy favourable socio-economic conditions that attract higher remittances), measurement error (remittances data were self-reported and less educated households might report remittances data less accurately) and non-random selection. To combat these concerns, and noting the fact that after a natural disaster a migrant household tend to receive larger than usual amount of remittances (Clarke

and Wallsten 2004), I use a natural experiment of rainfall driven remittances interacted with cyclone-affected migrant household's (hereafter, the treatment group) distance to nearest weather station to construct an innovative cross-sectional instrument that provide an experimental measure with respect to the impact of remittances.

[Insert Figure 1, about here]

To track plausibly exogenous variation in remittances receipts that is uncorrelated with cyclone-affected household's socio-economic conditions, I use variation in average local rainfall. As Figure 1 shows, remittances sent to the cyclone-affected households in southern Bangladesh are negatively correlated with household-level rainfall measure (first stage relationship)[13]. Specifically, I interact the exogenous variation in the deviation of district level average aggregate rainfall from its long-run trend with cyclone-affected household's distance to nearest weather station (located in nearest town centre) as instrument for remittances. The instrument therefore identifies the average treatment effect for households who suffered losses due to the landfall of cyclone-Roanu in southern Bangladesh.

For a total sample of 610 households where 105 households have one or more member living and working abroad, the IV results show that remittances foster the probability of using LPG for cooking. The results find that for a 1,000 Taka increase in household's remittances income the probability of choosing LPG over other fuel for cooking will raise by 1%. These findings are robust to alternate specifications, to alternative instruments, to possible omitted variable bias arising from post-cyclone recovery expenses financed through remittances[14] and potential violations of the exclusion restriction. There are four plausible channels through which rainfall driven instrument could affect the probability of using LPG for cooking independent of remittances flows: domestic income from other

[13] Inadequate rainfall leads to crop failure and remittances respond in opposite direction.
[14] Remittances flowing in to finance damages due to cyclone during same time. Control for q132

sources, food and housing expenditures, labour market participations and access to credit. The findings are robust to specifications that take these other channels into account.

The results obtained in this paper, however, do not suggest that remittances promote inter-fuel substitution by inducing biomass-consuming households to switch into cleaner alternatives such as LPG. The dynamics of fuel switching is a complex issue with a high degree of inertia in fuel switching patterns with non-economic factors often playing important roles (Karimu et al., 2016). Rather, the findings pioneers the role of migrant remittances as a key influencer of household's choice for cleaner fuel for cooking like LPG over alternate fuels. Nonetheless, the findings do uncover a welfare enhancing function of remittances in a migrant household: improve the access to affordable modern energy.

The reminder of the paper is structured as follows: Section 2 provides the review of relevant literature. Section 3 discuss the empirical strategy and data. Section 4 presents the results and section 5 provides the conclusions.

2. Review of Literature

A large group of scholars have studied the determinants of household energy consumption. The "energy ladder hypothesis" places heavy emphasis on household income in explaining fuel-switching where households observe transition from traditional biomass fuel to modern fuel such as LPG, kerosene, or electricity (Leach, 1992; Barnes, Krutilla, and Hyde, 2005). Various socio-economic factors are also found to influence energy consumption. Social and demographic factors such as education, household size, age of household head, type of shelter and its ownership status, house location and distance from forest are important determinants of energy choice (Gupta and Köhlin, 2006; Heltberg, 2005; Hosier, 1985; Ouedraogo, 2006; Rehfuess et al., 2010). There are also other non-cost factors that affect energy demand such as local food habits and cooking frequency (Ouedraogo, 2006), ethnicity (Heltberg, 2005), local traditions and institutions (Hiemstra-van der Horst and Hovorka, 2008) and food taste preferences (Karekezi and Majoro, 2002; Leach, 1988). The

issue of gender and women's position within a household is also considered a key factor driving energy choice (Heltberg, 2004; Gupta and Köhlin, 2006; Rehfuess et al., 2010). Other potential drivers of energy choice are related to market availability or access, including LPG and electricity, social status, reliability concerns over service delivery and distributional constraints (Arnold et al., 2006; Campbell et al., 2003; Davis, 1998; Gupta and Köhlin, 2006; Hosier, 1985; Karekezi and Majoro, 2002; Kebede et al., 2002; Odihi, 2003; Rehfuess et al., 2010).

Nevertheless, economic factors remain a key constraint to the household's transition from the use of traditional fuels to modern and clean fuel types like LPG. For instance, Edward and Langpap (2005) find that a significant constraint on the adoption of LPG is insufficient income[15]. Similarly, Khandker et al (2012) find that low adoption of clean energy is prevalent among the urban-poor households despite the availability of and access to modern energy such as LPG and electricity being higher in urban areas. The studies highlight the importance of income factor in household's energy consumption and transition to modern energy, but do not suggest if a specific income source is more impactful. This paper contributes to the literature by showing that remittances income is an important source that facilitates migrants household's transition to modern energy.

There is a large body of theoretical and empirical literature on the causes and functions of overseas migrants' remittances. Scholars have identified various cost and benefit accrued to the household as a result of remittances inflows to the migrant's family. In general remittances are perceived to perform welfare improving functions for the recipient households. For instance, remittances reduce poverty (e.g. Gupta et al., 2009; Adams and Page, 2005), improve education and health (Alcaraz et al., 2012; Ambler et al., 2015; Cox-Edwards and Ureta, 2003; Frank and Hummer, 2002), relax household credit constraints (Chiodi et al., 2012) and reduce interpersonal conflict (Hassan and Faria, 2015). However, no previous study has rigorously explored the relationship

[15] Because LPG use requires an upfront investment on the purchase of a gas stove.

between remittances and energy consumption, and investigated the causal effect remittances play in alleviating household's energy poverty.

To fill this gap, this paper isolates a new driver for household's selection of clean energy on which previous studies have not focused: remittances from family members working overseas. The novelty of the project emanates from the integration of two distinct literatures covering household wellbeing – remittances and energy, and from the creation of an innovative instrument to credibly identify the impact of remittances.

3. Empirical Strategy

3.1 Regression equation of interest

The paper aims to estimate the causal effect of remittances on a household's decision to use clean energy for cooking such as LPG. The regression equation of interest is given by a probit model for probability of using LPG for cooking. More formally, let an outcome, LPG_i^*, representing the (latent) decision to use LPG for cooking, be modelled as a linear reduced form as follows:

$$LPG_i^* = \beta_0 + \beta_1 REMIT_i + \beta_3 \boldsymbol{X}_i + e_i \quad [1]$$

Where LPG_i^* is not directly observed, but the binary variable LPG_i equals to 1 if $LPG_i^*, > 0$ when the household *i* uses LPG as a cooking fuel and equals to 0 if $LPG_i^* \leq 0$ when they do not. The independent variable of interest is $REMIT_i$ which is the amount of monthly average of remittances money the household *i* receives from overseas measured in local currency (*Taka*). According to the mechanism described in section 1, remittances received by the households would enhance the prospect of their using clean fuel sources for cooking. This means the coefficient on the $REMIT_i$ term (β_1) should be positive.

$\boldsymbol{X}_i$ is a set of household characteristics (size of household, number of female family members, number of working female members, number of female students aged above 7, number of school going children below 7, number of overseas migrants, number of years migrant living abroad),

economic factors (acres of agricultural land owned), household head characteristics (age of household head, education and profession). Finally, e_i is a standard normally distributed residual assumed independent of the independent variables.

3.2 Endogeneity

A concern with the regression equation of interest is that attempts to gauge the causal impact of remittances on LPG use will suffer from endogeneity bias. The direction and magnitude of this bias, however, are likely to be influenced by the relative effects of reverse causality and measurement error.

On the former, the decision to migrate and remit earnings is often driven by poverty and a dearth of economic opportunities in the home country, which tend to correlate with the household's choice of energy for cooking. If a household's underlying choice of a less cleaner fuel source is positively correlated with the receipt of remittances, this will tend to bias downward the effect of remittances on clean energy for cooking. On the latter, mismeasurement of remittances does not seem to be random: poorer households, presumably with lower tracking capacities because of their low level of numeracy, are more prone to mismeasure remittances receipts. From an econometric standpoint, the prevalence of underreporting and existence of systematic measurement error tend to attenuate the coefficient estimate of remittances on household's choice on clean energy. Thus, the existence of non-random measurement error will tend to downward-bias the coefficient estimates.

3.3 Natural Experiment

One strategy to mitigate this endogeneity problem is to identify an instrument for remittances. I use a natural experiment linking plausibly exogenous variation in local rainfall in three districts of southern Bangladesh interacted with the cyclone-affected households (treatment group) distance to the nearest weather station.

Two stylised facts make this an interesting natural experiment. First, the amount of remittances received by the cyclone-affected households tracks the variability of local rainfall. A major

determinant of fluctuations in crop yield is year-to-year changes in climatic variables (Anderson and Hazell, 1987). The main agricultural crop in Bangladesh is rice (*Oryza sativa*) which contributes significantly to the employment and livelihood of the rural people (Government of Bangladesh, 2014). Furthermore, among the different varieties the yield of the major rice crop *Aman* (sown in July-August and harvested in November-December) in southern Bangladesh is almost entirely rain-dependent (Sarker et al., 2017). The volume of rainfall during the wet season of July to September when *Aman* is sown is therefore a critical determinant of crop yield and so the wet seasonal rainfall is a good predictor of remittances which like an insurance responds to income shocks (Yang and Choi, 2007). Thus, the wet seasonal rainfall provides a plausibly exogenous source of variation in remittances inflow that is unrelated to economic and social conditions of the households in southern Bangladesh.

The second stylised fact is that overseas migrants boost the amount they remit to their families immediately after a natural disaster in the home country (Bragg et al., 2017[16] ; Mahapatra et al. 2012 and Clarke and Wallsten 2004). Therefore, a fair share of remittances received by the households in the treatment group is likely to emanate from the overseas migrant's emergency response to losses suffered by the family due to the landfall of the cyclone-Roanu in Bangladesh[17]. These two stylised facts underlie the construction of the instrument. Specifically, I interact the exogenous variation in the deviation of district level average aggregate rainfall from its long-run trend with the cyclone-affected household's distance to nearest weather station (located in nearest town centre) as instrument for remittances.[18] The instrument therefore identifies the average treatment effect for households who suffered losses due to the landfall of cyclone-Roanu in southern Bangladesh.

This identification strategy is similar to that employed by Yang and Choi (2007) to gauge the impact of rainfall driven income shock on remittances flows. This paper's instrument differs from that of Yang and Choi on two key dimensions. It instruments for remittances rather than for household's

[16] (Remittances as aid following major sudden-onset natural disasters)
[17] Data on remittances was collected within six months after cyclone-Roanu's landfall.
[18] There are thirty five weather stations all over in Bangladesh. Among these three weather stations – Bhola, Khepupara and Patuakhali – are located in the study area from the distance to the household was calculated.

income, and it utilises a natural experiment for identification rather than using a panel data. On the former I focus on the level relationship between the preceding period's rainfall and the current period's remittances receipts. Specifically, it instruments current period's (i.e., 2016) level of remittances, with preceding rainy season's (i.e., 2015) level of rainfall measured as the deviation of the average precipitations from its long-run trend during the period when *Aman* rice is sown. The idea is that inadequate rainfall in the preceding sowing season will most likely reduce current period's *Aman* yield below the trend level severing current family income to which remittances respond by moving in the opposite direction. And, on the latter, I utilise a natural experiment framework that minimises the problem of omitted variables bedevilling cross-sectional research to measure the impact of remittances by using a rainfall driven instrument interacted with a natural shock.

Armed with this instrument, the structural-model approach is:

$$Second\ Stage: LPG_i^* = a + b \times REMIT_i + \delta \boldsymbol{X}_i + u_i, \qquad [2]$$

$$First\ Stage:\ REMIT_i = \alpha + \beta(DIST_i \times RAIN_j) + \delta' \boldsymbol{X}_i + \ \varepsilon_i, \qquad [3]$$

The structural equation [2] (second stage) is of main interest where the dependent variable LPG_i^* is latent and hence not directly observable. Instead the observed binary outcome LPG_i equals to 1 if LPG_i^*, > 0 when the household *i* uses LPG as a cooking fuel and equals to 0 if $LPG_i^* \leq 0$ when they do not. The reduced form equation [3] (first stage) explains the variation in the endogenous variable, $REMIT$, in terms of strictly exogenous variables, including the IV $(DIST_i \times RAIN_j)$ that is excluded from the structural equation. As in the linear instrumental variable estimator, Amemiya's generalised least square (AGLS) or the instrumental variables probit (IV-probit) model is estimated in a two-stage process. The structural-model approach completely specifies the distributions of *LPG** and *REMIT* in [2] and [3]. Consistent estimation is based on the assumption that $(u_i\ , \varepsilon_i)$ are independently and identically distributed multivariate normal. Violation of this assumption requires clustered standard errors to control for the lack of independence (Maddala, 1983). The standard errors in the first and second stage are conservatively clustered by villages to allow for arbitrary correlation in the error

structure. Moreover, because the two equations are estimated jointly, the errors in the second stage take into account the estimation error in the first stage.

In the structural equation or the second stage regression, the coefficient on remittances income will measure the "average treatment effect" for a group of households who received remittances from overseas *and* was affected by the cyclone-Roanu.[19] Finally, the instrumental variable results are generalisable, if the households in the control and treatment groups do not differ on pre-treatment observable characteristics. For instance, during the treatment period, the typical remittances receiving cyclone-affected household and non-affected household did not differ on household head's age and education up to higher secondary level, number of children above and below 7 years of age, distance to forest, number of overseas migrants or average remittances receipts.[20]

3.4 Identifying assumption

The identification assumption maintained in the empirical strategy is that the instrument – district level rainfall interacted with cyclone-affected household's distance to the nearest weather station – affects the probability of using LPG as a cooking fuel only through remittances. An important concern with regard to the identifying assumption is that all households in a local area get affected by rainfall. Because of this, at least part of the effects found in the likelihood of using LPG may be due to locality-level economic conditions violating the exclusion restriction criteria. Several possible channels and mechanisms are conceivable to stem from the localised economic conditions that might contaminate the identification. Rainfall might directly affect probability of household's LPG consumption independently of remittances through the local economic conditions such as the labour market,

[19] The "control" or "counterfactual" group therefore is the group of remittances receiving households who were not affected by the cyclone-Roanu.

[20] Across the treatment and control groups, the p-value on t-statistics (reported in parentheses) comparing the group means on household head age (0.06), education up to higher secondary level (0.84), number of children above 7 (0.14), number of children below 7 (0.19), distance to forest (0.28), number of overseas migrants (0.35) and average remittances receipts (0.12) are not statistically different from each other at the 5% confidence level.

income from other sources and certain types of household expenditures. Another conceivable factor originating from the localised economic condition that could directly affect the probability of using LPG is the availability and access to credit. To safeguard the results of the study from the potential violation of the exclusion restrictions, it is ensured that the findings are robust to specifications that take these channels that might potentially contaminate identification into account.

3.5 Data and summary statistics

The data was collected through a household survey from three coastal districts - Bhola, Barguna, and Patuakhali - of the Barisal division in southern Bangladesh.[21] These districts are the most affected zones from frequent cyclones according to the Disaster Management Bureau (DMB) of Bangladesh. From each district, an upazilla (sub-district) was selected including Monpura from Bhola, Amtoli from Barguna and Kalapara from Patuakhali. For the purpose of data collection two unions from each upazilla were identified based on the DMB's information about the number of affected households from Cyclone-Roanu which made landfall in 23rd May 2016. Applying the "Two stage sampling methods" based on the Kish Grid/Allocation formula,[22] a simple random sampling (SRS) was used to pick two villages from each union for the purpose of conducting the household survey. Thereafter, the systematic random sampling was employed to pick at least fifty households to survey from each village to finally enable a sample size of 610 households that were interviewed with the aid of a structured questionnaires.[23] The survey began in October 2016 and was fully completed by November 2016.

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[21] Administratively, Bangladesh has 6 divisions, 64 districts or zilas, 508 sub-districts or upazilas and 4466 unions. The term 'union' refers to the lowest administrative unit in the rural areas of Bangladesh. Under the Village Chaukidari Act of 1870, villages were grouped into unions to provide for a system of watches and wards in each village.

[22] Sample size was determined according to the following formula: $Sample\ Size = n_{initial} = \frac{N^2 + Z^2 + S^2}{MOE^2}$; Where, **N** = Total number of beneficiary households= 818,137; **Z =** Critical value from Normal Probability Distribution = 1.96; **S=** Standard deviation of the distribution of beneficiary data = 0. (Assume that since beneficiary data is not available) and, Margin of error (MOE) to be +/- 5% with 95% confidence interval. Sample size for random sampling is determined at 400 for household population size of 818,137. Considering the two stage sampling procedure, the design effect (DE) has been fixed at 1.5. This allows the sample size to be determined approximately at 600 households.

[23] There were six data collectors for three districts with two for each Upazilla. On average, each data collector interviewed five household respondents per day. A field-coordinator was assigned to ensure the quality of the household survey. Prior to the main household survey, a pilot survey was conducted to improve the final

The dependent variable is a binary variable which equals to 1 if the household head has responded yes to the question whether cylinder gas is used in the house for cooking purposes. The key independent variable is remittances received from overseas migrant member. It is a continuous variable measured in thousands of unit of local Bangladeshi currency (Taka). The data represents the average amount of remittances the family receives per month.[24] Other independent variables include household head's characteristics (age, education and occupation); demographic information (household size, number of female members, number of female students age 7 or above, number of children below 7 and number of children below 7 attending school), and various socio-economic characteristics (average monthly domestic income, average monthly health expenditures, average monthly food and housing expenditures, acres of agricultural land owned, amount of outstanding loan, access to clean water and sanitation, and ownership of other short-term assets).

[Table 1, about here]

Table 1 presents the summary statistics for 610 households used in the empirical analysis. Migrant households are those with overseas workers in October 2016. The 105 migrant household represent 17.2 percent of the sample of households. The table begins with presenting the summary statistics of variables used in constructing the instruments. Two rainfall measures are reported – wet and dry seasonal rainfall. The key instrument is the deviation of average wet-seasonal rainfall in 2015 from its long-term trend. The deviation of average dry-seasonal rainfall in 2015 from its long-term trend is used as an alternative instrument for remittances. Another alternative instrument used is the deviation of the average yield of *Aman* rice from its long-term trend. The alternative instruments are used for robustness check. The rest of the table summarises all variables used in the empirical analysis.

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version of the questionnaire. For successful completion of the fieldwork, enumerators with graduate level degrees in social science subjects were selected. A day long orientation was conducted involving the enumerators whose main job was to collect qualitative and quantitative data from the targeted villages. The training included a detail discussion of each question on the questionnaire as well as how to record the questionnaire data for each household survey. Since the data collection method was mobile app based with inclusion of recording the global positioning system (GPS) of each household, importance of maintaining highest level of consistency in data collection was communicated during the training program.

[24] The question used to collect remittances data is: "On average, how much money does he(/she/they) send home per month?"

4. Results

4.1 Instrumental variable approach

The results are presented in Table 2 starting with the probit model which is estimated as a baseline regression to compare the magnitude of bias, if any, with respect to the IV-probit estimations (see; columns 1-2). It is recognisable that the probit model underestimates the effect of remittances income. Whilst this downward bias is not large, the Wald test do clearly reject the assumption of exogeneity (Chi-square statistic = 5.96 with p-value = 0.02) favouring an instrumental variable approach.

The rest of table 2 presents the main results from the IV-probit regression and the corresponding marginal effects. The first stage is presented in the lower panel of Table 2. Looking into the main coefficients of the first-stage of the IV-probit regressions, few things are immediately noticeable. First, the instrument – interaction of rainfall and household's distance to weather stations – demonstrates a statistically significant effect on remittances. Second, the coefficient estimate of the instrument has a negative sign which is expected and confirms the first-stage relationship illustrated in Figure 1; a decrease in the instrument (lower rainfall than the historical trend) induce a positive effect on inflowing remittances. So, the instrument indeed has a significant negative effect on remittances. Third, the tables also show that the estimated F-statistics on the excluded instrument except in column 3 are smaller than the conservative threshold of weak instruments of 9.6 suggested by Stock, Wright, and Yogo (2002). In practice, however, there is no clear critical value for the F-statistic to test for instrument relevance because it depends on many factors (Cameron and Trivedi, 2005, 2009). Furthermore, weak instruments are usually not a problem in just-identified models

provided the instrument is significant in the first-stage (Angrist and Pischke, 2008, p. 209 and Angrist and Pischke, 2009).[25]

[Table 2, about here]

Nonetheless, to account for the low first-stage F-statistics, the Anderson-Rubin confidence intervals (AR CI) are reported throughout main regressions of the paper. It would increase the readers' trust in the instrument if these confidence intervals did not include zero. Indeed, the first-stage panel results at the end of Table 1 show that this is the case with all of the paper's main results.

The second-stage estimates are presented in the upper panel of table 2. The most important result is the positive marginal effect of remittances on household LPG choice; see columns 2-5. The effect is not only statistically significant, but also substantively meaningful: a unit increase in remittances income, which is equivalent to a thousand local currency, corresponds to a roughly 1% higher probability of choosing LPG as a cooking fuel by the household. In terms of percentage change, a 10% increase in remittances income lead to a 2.2% increase in the likelihood of using LPG (column 3).[26] These marginal effects clearly reveal the substantial role overseas remittances play in migrant households' decisions to choose cleaner fuel sources.

Across the IV-probit regressions in table 2, the control variables have the expected effect on LPG choice. Age, demography, asset holdings, education and occupation are found to have significant

[25] According to Angrist and Pischke (2008, page 209) and Angrist and Pischke (2009), as long as the first-stage coefficient is not zero, weak instruments are usually not a problem in just-identified models as the bias on the coefficient of the endogenous variable resulting from a weak instrument is not "serious". According to Angrist and Pischke (AP), any problems with too weak instruments in just-identified models are mirrored in the standard errors of the second-stage but they do not cause the second stage to be biased. This paper indeed shows significant second-stage effects; following the argument by AP this implies that the weak instrument does not seriously bias the effect of remittances. The key message in Angrist and Pischke (2009, page 1) is: "[…] bias with a just-identified model is not usually worth worrying about because if the instruments are so weak that just-identified IV is seriously biased, then you'll easily see the cosmic weakness of your first stage in such cases by virtue of large second-stage standard errors."

[26] The model in column 3 where log of remittances is instrumented is easy to interpret and its first stage F exceeding 9.6 threshold.

marginal effects on the choice of LPG fuel. The results are similar to the previous scholarly works in the literature.

Three alternative measures of the endogenous variable: remittances, logarithm of remittances and remittances per migrant worker were instrumented to compare the effect of remittances on the likelihood of LPG choice. It is already found that whether measured in local currency unit (column 2) or in logarithm (column 3), remittances do significantly enhance the likelihood of choosing LPG for cooking among rural households in southern Bangladesh. Finally, when remittances per migrant worker is instrumented, it is also found that for every thousand taka increase in remittances sent per migrant, a half percentage point increase in the probability LPG consumption is estimated.

I also check the sensitivity of the results by employing alternative instruments. The main instrument used throughout the paper is calculated based on the wet-seasonal (July-August) rainfall. However, in some parts of the study area the rice crop *Aus* is also cultivated. This crop is not entirely rainfed like *Aman* but dependents to some degree on the dry-seasonal (March-April) rainfall when it is planted. I use the dry-seasonal rainfall data to construct an alternative instrument. Column 4 presents the marginal effects of remittances using this alternative instrument. The instrument has a negative coefficient and is significant. Furthermore, hardly any noticeable change is observed on the marginal effect of remittances on LPG consumption.

I further explore the available data on crop productivity in the study area to utilise it as an alternative instrument. Conceptually, remittances respond to rainfall only because the latter generates shocks to household's income through agricultural production. The yield variability of the major rice crop *Aman* should therefore provide a credibly exogenous source of variation in remittances and serve equally as good as a relevant instrument for remittances as rainfall. Thus, utilising the deviation of *Aman's* annual yield from its trend as instrument, I estimate another IV-probit regression which is presented in column 5. The new instrument possesses a negative sign and

significantly affects remittances and the corresponding marginal effect of remittances on the probability of using LPG is positive and significant in the second stage.

Existing theory posit that substitution towards cleaner fuel sources requires households to be sufficiently health concerned. So, the mechanism working behind the effect of remittances to pass-through on to the adoption of clean energy is likely to be mediated via the health channel of the migrant households who, in general, put a greater emphasis on the health capital. So, it is unlikely that a noninsignificant effect will be observed for the interaction of remittances and health expenditures of the households. Instrumenting directly for this interaction term (and controlling for its constitutive parts) generates a positive and significant marginal effect reported in column 7. The significant coefficient estimate captures the heterogeneous effect of remittances conditional on household health expenditures; i.e., the marginal effect of remittances on the probability of using LPG increases as the household spends more on health. In other words, remittances and health expenditures are complementary in influencing the probability of using LPG as a cleaner fuel source.

4.2 Sensitivity analysis

Alternative specifications: The heterogeneous effect of remittances being conditional on household's health spending suggests health expenditure matters. In specification that control for household health expenditures where only remittances are instrumented, the marginal effect of remittances on the probability of using LPG remains positive and becomes comparatively stronger – a unit increase in remittances raises the probability of using LPG by 1.6% (Table 3, column 1).

[Table 3, about here]

Furthermore, the complementarity remittances and household health spending suggests that the overall provision of health and hygiene facilities in the dwelling matter for clean energy choice, especially when lack of safe water supply and hygienic sanitation pose a significant health risk to rural Bangladeshi households. So, it is reasonable to expect that the magnitude of the marginal effect of

remittances is likely to depend on the provision of water and sanitation facilities inside the house like running tap water, deep tube well, water filter and hygienic sanitary latrine. In specifications these indicators variables interacted with the health expenditures are controlled for, the marginal effects of remittances remain positive and substantive while at the same time demonstrate considerable variability in response to the different types of facilities that are controlled for. For example, a unit change in remittances raises the probability of using LPG by 0.7% when tap water facility is controlled for (column 2), but when the existing facility of a sanitary toilet is controlled for, remittances raises the likelihood of using LPG is by 2.7% (column 5). Therefore, overseas migrants' remittances make the largest impact in households with hygienic sanitation facilities conditional on health spending.

Outliers: The main findings are also robust to controlling for outliers in the data (results are not reported). The main effect of remittances on LPG usage remains positive after removing influential outlier on the endogenous variable.

4.3 Robustness check

I discuss here evidence against alternative channels (other than remittances) of the instrument's effects, and against an important potential confounding factor (expenditure undertaken by households to mitigate home damage caused by cyclone-Roanu).

4.3.1 *Potential violation of exclusion restrictions*

An important concern with regard to the identifying assumption is that all households in a local area get affected by rainfall. Because of this, at least part of the instrument's effects in the likelihood of using LPG may be due to locality-level economic conditions violating the exclusion restriction criteria. Several possible channels and mechanisms are conceivable to stem from the localised economic conditions that might contaminate the identification. First, rainfall might affect the probability of household's use of LPG independently of remittances through impacting the localised economic conditions in a manner that could affect the sources of household's domestic income other than remittances. For instance, the sources of household income stemming from production activities

related agriculture or fishing can be directly affected by rainfall as well as other weather conditions. Second, on a same note, rainfall driven conditions can also affect household expenditures impacting the probability of using of LPG. Not all types of household expenditures are likely to be affected by locality-level activities affected by rainfall. Household expenses like food and housing might covary with local economic conditions and are likely to affect the likelihood of LPG use. For instance, rainfall might disrupt the supply chain for local food production and cause a shock to household's food budget which might transmits to energy consumption. Also, weather related conditions may lead households to renovate kitchen or upgrade to a modern cookstove which might affect LPG consumption. Third, rainfall could influence household's labour supply response and affect the likelihood of using LPG independently of remittances via the local labour market condition by. For example, inadequate rainfall may directly reduce the probability of using LPG by depressing local labour market conditions and cutting working hours incentivising household members to collect and use fuelwood for cooking purposes. Fourth, rainfall can also affect LPG consumption independently of remittances through the credit channel. Onset of weather-related conditions might generate greater demand for credit for the purpose of either smoothing consumption or undertaking minor investments. For instance, credit may facilitate the purchase of a gas-stove by paying for the upfront cost that subsequently increases the probability of using LPG.

To test whether such concerns have any basis, it is useful to test the stability of the marginal effects coefficients of the IV-probit estimations in the Table 2 (column 2) to the inclusion of control variables likely to violate the exclusion criteria in various alternative channels. In particular, I include control variables for household domestic income, food and housing expenditures, working adult members in the house and amount of credit. Any substantial change in the IV estimates when including these control variables would cast doubt on the assumption that the effects of rainfall are working primarily through remittances. The main results are presented in Table 4. None of the impacts of these variables are found significant on the probability of household's using LPG relieving IV-probit estimates from the worry of any identification problem. Furthermore, the marginal effect coefficient

of IV-probit estimates are stable; there is also no evidence that having controlled for these alternative channels there is any substantial impact on the signs or magnitudes of the marginal effects of remittances on the probability of using LPG (see columns 1-4).

[Table 4, about here]

4.3.2 Omitted variable concern due to cyclone-Ruano

Another general identification issue arises when the paper uses a natural experiment by using plausibly exogenous variation in rainfall interacted with cyclone-affected migrant household's distance to the local weather stations as instrument for remittances. Although various socio-economic characteristics of the household have been controlled for, a possible omitted factor could be the affected household's post-disaster mitigation expenditure. A part of overseas remittances received in the aftermath of the cyclone-Roanu might have been allocated to finance the rebuilding cost of the damaged property such as renovating the kitchen or increasing the number of rooms or floors causing a change to the structure of the house that might subsequently affect the composition of household's energy demand. Such possibility may cause an omitted variable bias.

Therefore, I control for the amount (in thousands of local currency) of household's explicit expenditures on home improvement (rebuilding work related to the house and in the homestead area) in the aftermath of cyclone-Roanu. Having controlled for the variable – post-Roanu expenditure on home improvement – no noticeable change is observed in the estimated marginal effect of remittances (see column 5 in Table 4) on the probability of LPG use and the variable is has no significant effect on the dependent variable.

5. Conclusion

The substitution towards the use of cleaner fuel sources requires households who make decisions to be sufficiently aware of their health capital, a virtue frequently observed in a migrant household due partly to their higher propensity to invest in human capital predominantly financed through the overseas remittances receipts. Building off this logic, I use a natural experiment of rainfall-driven

remittances that provide robust cross-sectional evidence that remittances foster probability of using LPG as a fuel for cooking over other alternative fuels by the rural households in Bangladesh. The finding linking remittances to clean energy counters some existing case studies and views of many policy makers that economic factors are less significant relative to non-economic factors to shift households towards better cleaner fuel sources.

It is often claimed that migration can contribute to improving access to affordable modern energy services through higher incomes for migrants and the sending of remittances. However, until now there has been no robust evidence using microdata on households in developing countries that remittances generate a causal impact on the use of modern energy. This paper fills this gap through a credible identification of the impact of remittances to raise the probability of using LPG or cylinder gas for cooking using household survey data collected from the Bangladesh that includes data on remittance receipts from overseas migrants and the choice of LPG for cooking.

Household choice of clean energy (LPG) and remittances are jointly related, making an instrumental variable approach necessary. In particular, plausibly exogenous variation in rainfall interacted with cyclone-affected migrant household's distance to the local weather stations is used as instrument for remittances. In households with overseas migrants, the paper finds that exogenous increase in remittances income causes an increase to the probability of using LPG as cooking fuel. Because the treatment of remittances is randomly assigned to households affected by the landfall of cyclone-Roanu, the instrument identifies the average treatment effect for the treatment group, i.e. the cyclone-affected remittances recipient households.

Health awareness is a critical enabling factor for household's transiting towards cleaner fuel sources. Unsurprisingly, the channel enabling the impact of remittances to pass-through on to selecting cleaner energy for cooking is the household health expenditure suggesting that remittances and health expenditures are complements. Furthermore, the marginal effect of remittances on raising

the probability of using LPG is conditionally positive on the level of household health expenditures and it gets stronger with inclusion of the indicators for water and sanitation factor.

Finally, the logic that motivate households to utilise remittances money for the purpose of better cleaner fuel should, for the same reason, discourage them from using potentially hazardous biomass fuel. Interestingly, the natural experiment employed in this paper can explain household's choice of biomass fuel. And reassuringly, rainfall-driven remittances are found to reduce the probability of using animal dung and leaves and of fuelwood as household's fuel sources. The marginal effect of remittances in reducing the probability of combusting animal dung and leaves is found to be significant [27]. This corroborative evidence supports the general conjecture of the paper that remittances cause households to choose better cleaner fuel, such as LPG, and improve their access to affordable modern energy.

[27] The marginal effect of remittances for dung and leaves is – 0.023 with a standard error of 0.005 (p-value = 0.00). And the marginal effect of remittances for fuelwood is – 0.003 with a standard error of 0.011 (p-value = 0.81).

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FIGURE 1. RAINFALL AND REMITTANCES

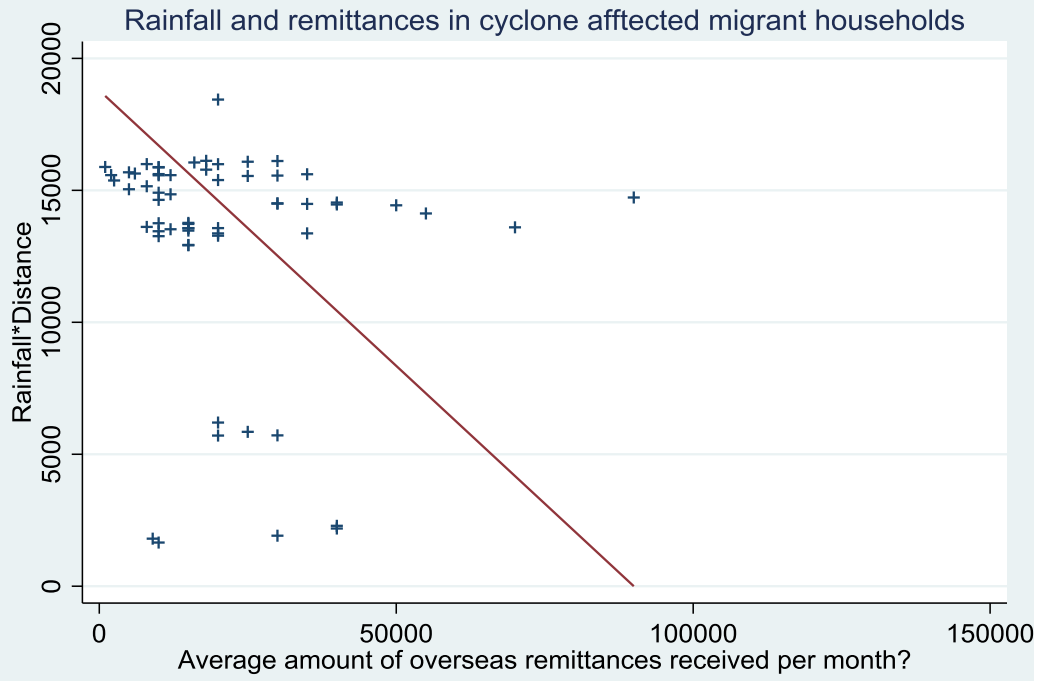

Figure 1

TABLE 1.— SUMMARY STATISTICS

VARIABLES	OBS	MEAN	STD. DEV.	MIN	MAX
WEATHER					
Rainfall_wet	3	275.518	16.715	251.82	288.37
Rainfall_dry	3	44.928	6.464	36.8	52.6
Yield of *Aman* rice	3	0.584	1.331	-1.2	1.94
HOUSEHOLD HEAD (HH) CHARACTERISTICS					
Age	610	41.485	13.975	14	95
Age-squared	610	1916.016	1246.358	196	9025
HH EDUCATION					
Primary	610	0.441	0.497	0	1
Secondary	610	0.154	0.361	0	1
Higher Secondary	610	0.070	0.256	0	1
Madarasa	610	0.051	0.220	0	1
HH OCCUPATION					
Farming and Fishing	610	0.330	0.470	0	1
Wage earners	610	0.216	0.412	0	1
Shrimp farmer	610	0.305	0.461	0	1
Business	610	0.057	0.233	0	1
HOUSEHOLD DEMOGRAPHIC CHARACTERISTICS					
Total members	610	5.761	2.290	1	18
Total female members	610	2.777	1.457	0	12
Working male members	610	1.713	0.886	0	7
Working female members	610	0.163	0.431	0	3
Total children below 7 years	610	0.718	0.787	0	6
Total children below 7 years attending school	610	0.338	0.556	0	3
Total female children aged 7 or above attending school	610	0.675	0.804	0	7
MIGRATION AND REMITTANCES					
Number of overseas migrants	105	1.133	0.369	1	3
Number of years migrant living overseas	105	4.219	2.703	0	15
Average amount of remittances received per month	105	25690.48	19285.60	1000	150000
Log of remittances received per month	105	9.906	0.768	6.907	11.918
Average remittances received per overseas migrant	105	24273.02	19634.71	1000	150000

VARIABLES	OBS	MEAN	STD. DEV.	MIN	MAX
ENERGY AND ENVIRONMENT					
LPG or cylinder gas for cooking	610	0.136	0.343	0	1
Fuelwood for cooking	610	0.180	0.384	0	1
Dung and leaves for cooking	610	0.744	0.436	0	1
Is the house located near forest?	610	1.677	0.468	1	2
WATER AND SANITATION					
House has water filter	610	0.945	0.226	0	1
House has a deep tube well	610	0.807	0.395	0	1
House has tap or piped water	610	0.720	0.450	0	1
House has a sanitary toilet	610	0.900	0.300	0	1
HOUSEHOLD FINANCIAL CHARACTERISTICS					
Average domestic income per month	610	16894.75	14656.47	0	150000
Average food expenditure per month	610	6646.89	4137.53	700	45000
Average housing expenditure per month	610	410.98	640.83	0	5000
Average health expenditure per month	610	1648.77	1318.40	0	10000
Average education expenditure per month	610	1922.95	2196.35	0	20000
Amount of credit taken from NGO	610	22096.91	70034.37	0	1000000
HOUSEHOLD ASSETS					
Agriculture land	610	98.72	248.55	0	2660
Orchard	610	0.792	0.406	0	1
Poultry	610	0.543	0.499	0	1
Mechanised vehicle	610	0.226	0.419	0	1
Mechanised boat	610	0.382	0.486	0	1

TABLE 2.—REMITTANCES RAISE PROBABILITY OF USING LPG

Dependent variable = 1 if household uses LPG; otherwise 0.									
SECOND-STAGE REGRESSION:									
INSTRUMENTED VARIABLES:	Probit (1)		IV-Probit (2)		IV-Probit (3)	IV-Probit (4)	IV-Probit (5)	IV-Probit (6)	IV-Probit (7)
	Coef.	m.e.	Coef.	m.e.	m.e.	m.e.	m.e.	m.e.	m.e.
Remittances	0.079***	0.009***	0.117***	0.007**			0.007**	0.008**	
	[0.021]	[0.002]	[0.022]	[0.004]			[0.004]	[0.003]	
Log remittances					0.202***				
					[0.065]				
Remittances per migrant						0.004*			
						[0.002]			
Remittances × Health expenditure									0.006**
									[0.002]
CONTROL VARIABLES:									
Remittances									0.002
									[0.005]
Health expenditure									-0.354***
									[0.134]
Cons.	3.673		0.818						
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of observations	105	105	104	104	104	104	104	104	104
Wald exogeneity test			5.96**		8.55***	6.40**	6.44**	3.19*	7.11***
Log pseudolikelihood	-20.849		-409.842		-94.240	-411.753	-410.121	-411.009	-582.527
FIRST-STAGE REGRESSION:									
INSTRUMENTS:			(2) Dep. var:		(3) Dep. var:	(4) Dep. var:	(5) Dep. var:	(6) Dep. var:	(7) Dep. var:

	Remittances	Log Remittances	Remittances/ Migrant	Remittances	Remittances	Remittances × health
Rainfall_wet × distance	-0.001** [0.000]	-0.000*** [0.000]	-0.001** [0.000]			-0.003*** [0.001]
Rainfall_dry × distance				-0.003** [0.001]		
Rice_yield × distance					-0.095** [0.054]	
F-statistic on instrument	3.73	9.63	3.20	3.80	3.03	5.55
AR 95 CI	[0.050346, 0.184186]	[0.697904, 4.7862]	[0.061155, 0.152026]	[0.049531, 0.184121]	[0.044967, 0.193968]	[0 .010273, 0.026748]

Probit and IV-Probit regressions. Average marginal effects are reported. Robust standard errors, clustered by village, reported in parentheses. Significant at *10%, **5%, and ***1%. Remittances are measured in thousands of local currency, Log remittances and remittances per migrant. All specification include a vector of controls that includes size of household, number of female family members, number of working female members, number of female students aged above 7, number of school going children below 7, number of overseas migrants, number of years migrant living abroad, acres of agricultural land owned, and household head's age, education and profession.

TABLE 3.—REMITTANCES RAISE PROBABILITY OF USING LPG, ALTERNATE SPECIFICATIONS

Dependent variable = 1 if household uses LPG; otherwise 0.					
SECOND-STAGE REGRESSION:					
INSTRUMENTED VARIABLES:	IV-Probit (1)	IV-Probit (2)	IV-Probit (3)	IV-Probit (4)	IV-Probit (5)
Remittances	0.016***	0.007*	0.013**	0.015***	0.028***
	[0.004]	[0.004]	[0.005]	[0.004]	[0.009]
CONTROL VARIABLES:					
Health expenditures	-0.145***				
	[0.039]				
Tap water × Health expenditures		-0.01			
		[0.015]			
Deep tube well × Health expenditures			-0.081***		
			[0.028]		
Water filter × Health expenditures				-0.121***	
				[0.037]	
Sanitary toilet × Health expenditures					-0.256***
					[0.075]
No. of observations	104	104	104	104	104
Wald exogeneity test	8.08***	5.45**	10.56***	7.56***	15.44***

IV-Probit regressions. Average marginal effects are reported. Robust standard errors, clustered by village, reported in parentheses. Significant at *10%, **5%, and ***1%. Remittances are measured in thousands of local currency, Log remittances and remittances per migrant. All specification include a vector of controls that includes size of household, number of female family members, number of working female members, number of female students aged above 7, number of school going children below 7, number of overseas migrants, number of years migrant living abroad, acres of agricultural land owned, and household head's age, education and profession.

TABLE 4.—TESTS OF THE EXCLUSION RESTRICTIONS

Dependent variable = 1 if household uses LPG; otherwise 0.					
SECOND-STAGE REGRESSION:					
INSTRUMENTED VARIABLES:	IV-Probit (1)	IV-Probit (2)	IV-Probit (3)	IV-Probit (4)	IV-Probit (5)
Remittances	0.009*	0.007*	0.008*	0.007**	0.009*
	[0.005]	[0.004]	[0.004]	[0.003]	[0.005]
CONTROL VARIABLES:					
Domestic Income	-0.002				
	[0.004]				
Food and housing expenditure		0.012			
		[0.011]			
Working members in household			-0.024		
			[0.044]		
Credit from micro finance institutions				-0.001	
				[0.003]	
Post cyclone-Roanu home improvement expenditure					[0.003]
					[0.002]
Number of observations	104	104	104	104	104
Wald test of exogeneity	8.11***	3.55*	7.14***	6.21**	4.64**

IV-Probit regressions. Average marginal effects are reported. Robust standard errors, clustered by village, reported in parentheses. Significant at *10%, **5%, and ***1%. Remittances are measured in thousands of local currency, Log remittances and remittances per migrant. All specification include a vector of controls that includes size of household, number of female family members, number of working female members, number of female students aged above 7, number of school going children below 7, number of overseas migrants, number of years migrant living abroad, acres of agricultural land owned, and household head's age, education and profession.