Effect of remittances on farm productivity after a large natural disaster*

Prakash Pathak † Agnese Romiti † Sabin Subedi †

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This study investigates the impact of remittances on farm productivity in the aftermath of the 2015 Nepal earthquake, addressing a critical gap in our understanding of how private financial flows affect economic outcomes during times of crisis. Employing a triple difference strategy and using exchange rates as an instrument for remittances, we find that a 10% increase in remittances leads to a 1.5% decrease in farm productivity for earthquake-affected households. This effect is pronounced in the short term but dissipates by the third year post-earthquake. Our analysis reveals that remittance-receiving households prioritize immediate recovery needs over agricultural investments, suggesting a trade-off between short-term disaster relief and maintaining productivity in key economic sectors. The study utilizes comprehensive household survey data, and rigorous econometric techniques to establish causality. Our findings have important implications for policymakers in remittance-dependent countries prone to natural disasters, highlighting the need for integrated approaches that leverage remittances for immediate relief while supporting agricultural productivity.

*Correspondence: sabin.subedi@strath.ac.uk. This paper is a work in progress and only preliminary results are presented. All mistakes are our own.
† : Affiliated to University of Strathclyde

1 — Introduction

International migration is a phenomenon and vital way of life in South Asia as in many low- and middle-income countries(LMICs). Remittances, the funds sent by migrants to their home countries, is the largest source of external financing for these countries, even exceeding foreign direct investement (FDI) and overseas development assistance (ODA). In 2022 alone, there was flow of $ 651 billion in remittances to LMICs and it continues to rise (Ratha et al. 2024). Despite the importance of remittances, its impact on economic development is largely inconclusive. And even less is known about the role of remittances in the face of shock. In the aftermath of shocks like natural disasters, the lack of proper social insurance programs, lack of savings and borrowing contraints exacerbate the situation and hinder their way out of poverty. Developing countries are prone to risk of income loss due to natural disasters and conflicts. In such contexts, the flow of remittances becomes even more critical as households grapple with rebuilding their lives and livihoods. We address this gap in the context of devastating earthquake of 2015 in Nepal. We specifically ask: What is the impact of earthquake induced remittances on farm productivty?

In 2015, a powerful earthquake struck Nepal, causing widespread destruction and displacing thousands of households. Amid the chaos, remittances from abroad emerged as a critical support system for many families. Remittance response have shown to increase during the times of crisis and also dampen the economic damage acting as an insurnace mechanism (Yang and Choi 2007; Gubert 2002; Yang 2008a; Eldemerdash and Landis 2023; Combes and Ebeke 2011; Ebeke and Combes 2013). This is also evident by the resilience of remittances during Covid crisis (Ratha et al. 2021). However the broader economic implications of these remittances during shocks, particularly on agricultural productivity, remain unclear. Understanding this dynamic is vital as agriculture is a primary livelihood for significant portion of LMICs population.

The major empirical challenge in studying the impact of remittances is its endogenous nature. To deal with the endogeniety of remittances, we use intrumental variable method. We use exchange rate as an intrument for remittances. Second, we exploit the spatial variation in the intensity of earthquake and employ a triple difference strategy. It is important to note that we are not directly trying to identify the impact of remittances on farm productivity rather the impact of remittances during the time of disasters. In essense, we use the variation in time, earthquake intensity and remittances through exchange rate changes to get this causal answer. We find that a 10% increase in remittances results in 1.5% decrease in farm productivity for households that are affected by earthquake. Alonside showing that the identifying assumptions hold for instrumental variables and DID methdology, we show that the results are robust to variable transformation and alternative estimators.

This paper makes contribution in following areas. First, we provide evidence on the impact of remittances on farm productivity after a natural disaster, which is first in the literature. Closest to our study is (Klomp and Hoogezand 2018), which looks at the impact of agricultural protection measures on productivity in the aftermath of diaster. The reoccurence of natural disasters mainly due to climate change pose a threat to agricultural productivity in the coming decades. The disruptions and loss of agriculture prodiuctivity following a natural disaster can be detrimental to the livelihoods of people that depend on agriculture as primary occupation, which is the case in most of the developing countries. The direction of various approaches that are aimed at improving agriculture productivity is inconclusive. In this regard, we show that remittances have negative effect on farm productivity.

Second, our paper contributes to the understanding of disaster responses by household. Extreme weather events have become more frequent and they disporpotionately affect poorer countries(Hsiang, Oliva, and Walker 2019; Jakobsen 2012; Andrade Lima and Barbosa 2019; Fankhauser and McDermott 2014; Noy 2009). With remittances establishing as an important and resilient source of private assistance to households in developing countries, it is imperative to understand how remittances are utilized by households and it's impact on important economic outcomes like farm productivity. (Pathak and Schündeln 2022) in the same context show the evidence for discrimination and favoritism based on castes in the allocation of public funds after disasters, which leaves many households with only private assistance like remittances.

Third, our paper uses a comprehensive sample of both internal and international migrants. Our measure of farm productivity includes both crop and livestock income based on the market value at the time, which allows us to account for any structural changes in the patterns of agriculture and also households decision making behaviours (De Brauw 2020; Janvry, Fafchamps, and Sadoulet 1991). Further, Nepal as a context for this study is a fit because it is agrarian, remittance dependent country and lies in a earthquake prone area.

Our paper is related to various strands of literature. Our study is broadely related to the large literature that estimates the returns to migration (Mobarak, Sharif, and Shrestha 2023; Akram, Chowdhury, and Mobarak 2017; Theoharides 2017; Yang 2008b). And it also deals with the issue of endogeniety of remittances. It is also related to the literature of remittances as an insurance mechanism for households (Gubert 2002; Yang and Choi 2007; Yang 2008a). And specifically this study literature to a relatively scare literature of the impact of assistance on agriculture productivity after disaster (Klomp and Hoogezand 2018; Bastos, Straume, and Urrego 2013).

The rest of the paper is organized as follows. Section 2 gives a short background on migration, remittances and earthquake in Nepal. Section 3 explains the important variables and the data source used in the study. Section 4 explains the empirical strategy and identification. Section 5 shows the resutls, validity of design and robustness. Section 6 explains the possible mechanisms for the results, and section 7 concludes.

2 — Background

2.1. Migration and Remittances

Households in Nepal historically and till present depend on agriculture. In 2022, more than sixty percent of total people depended on agriculture, and it represent more than 20% share of GDP (World Bank 2023). And as shown in figure 2, remittances received has been steadily rising and the remittance to GDP share is above 20%. This makes Nepal an agrarian country dependent on remittances. Labour migration to foreign countries from Nepal is relatively a recent phenomenon, which picked up in 2000's. Before 2000's migration was mostly to India due to the open border, ethnic and linguistic similarities (Seddon, Adhikari, and Gurung 2002). In the 2000's the major destination for workers has been the countries in the Gulf, Malaysia, Japan and South Korea which is dominated by low skilled workers working in manufacturing and contruction sectors and mostly through recruitment agencies (Bank 2011; Seddon, Adhikari, and Gurung 2002; Shrestha 2019). From 2019/20 to 2021/22, Nepali people have migrated to over 150 countries and in 2021 about 7.4% of total population lived outside Nepal (MOLESS 2022; NSO 2023). Migration results in remittances, which are labour income sent back home by these migrants. Remittances have contribute highly to foreign exchange earnings, external sector validity and ofsetting trade deficit (Sapkota 2013).

The economic impacts of remittances in reducing poverty has also been noteworthy.

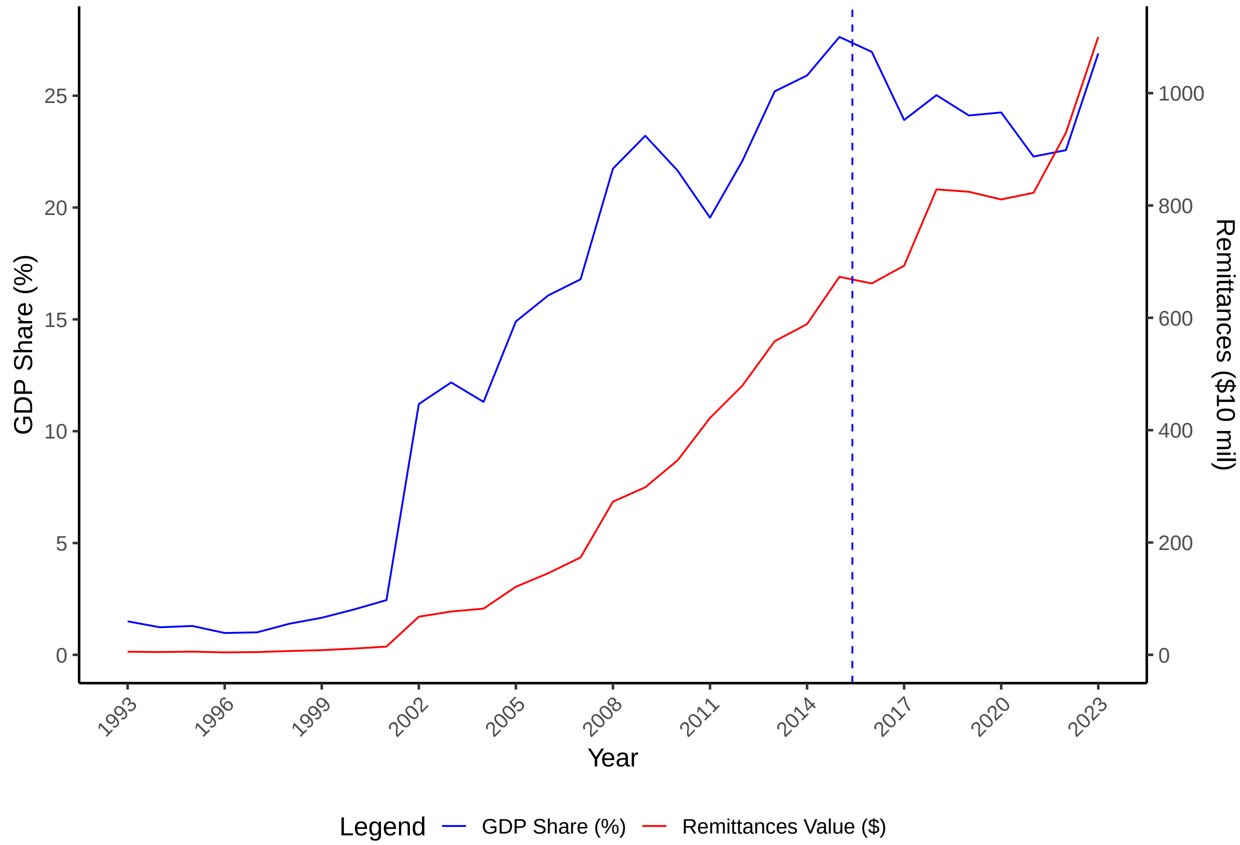
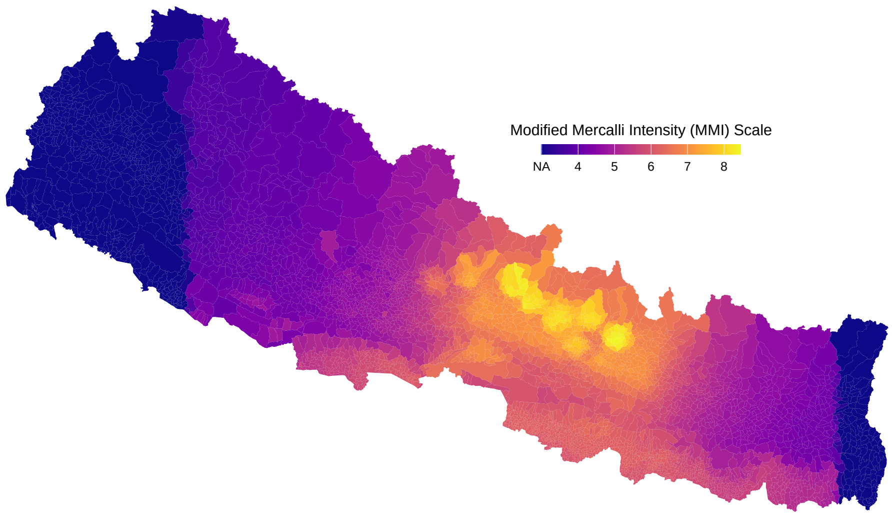


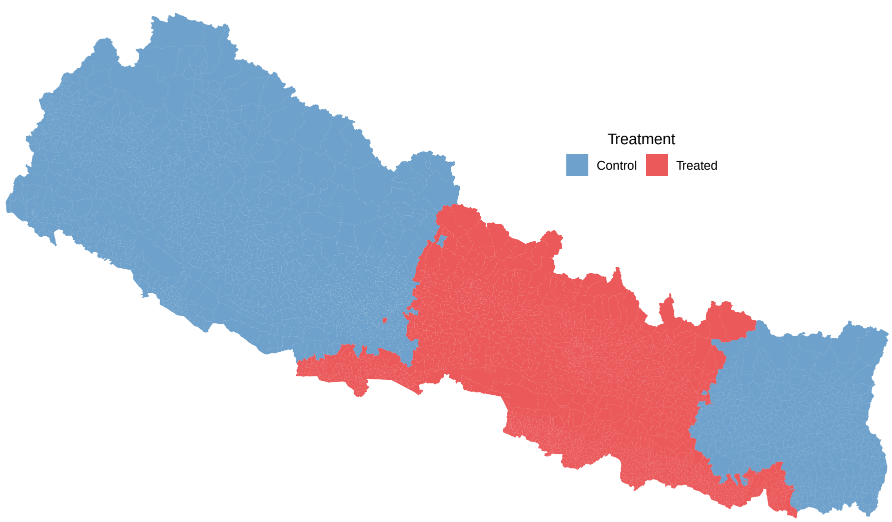
Figure 1 — GDP Share and Remittances Over Time

2.2. April 2015 Nepal Earthquake

The earthquake of April 2015 was one of the deadliest earthquake in Nepal. It resulted in significant loss of human lives and affected about 8 million people and resulted in economic damage of about ten billion dollars (USGS 2015; Goda et al. 2015). Disasters like such put households under immense pressure to recover from damages and economic losses (Rentschler 2013; Strömberg 2007). The suddenness of these events typically defies the possibility of adaptation or advance planning. This suddeness of earthquake creates need for resources to abosorb the damages caused and it typically defies possibility of adaptation and consequently increased the demand for remittances. International remittances itself are unaffected by the disaster. Remittance recieving households are in a unique position to deal with the damages. Remittances can help household to smoothen their consumption and even act as a mechanism for insurance. In this context, the impact of remittances on farm productivity can go either way. Remittances can increase or can help maintain current farm productivity by acting as a buffer for these damages. Remittances can decrease farm productivity due to shift in priorities, inability to work in farms or because of moral hazard problem (Azam and Gubert 2006).



(a) Ward Level Earthquake Intensity



(b) Treatment Assignment based on median split

Figure 2 — Earthquake Intensity and Treatment Assignment

Note: Panel (a) shows the spatial distribution of earthquake intensity across different wards. Panel (b) shows the treatment assignment based on above median MMI.

Source: MMI data from USGS and authors' calculations

3 — Data and Variables

3.1. Household Risk and Vulnerability Survey and Nepal Living Standards Survey

We use two household survey in Nepal, the third round of Nepal Living Standards Survey (NLSS) carried out it 2010/11 and Household Risk and Vulnerability Survey (HRVS) carried out in 2016 to 2018, which is a three-year panel survey (CBS 2011; World Bank 2020). NLSS follows the Living Standards Measurement Survey (LSMS) methodology developed by world bank and HRVS closely follows both questionnaire and sampling of NLSS to ensure comparability. Both of the survey are comprehensive household survey that includes rich information on demographics, income, investment, migration, employment, agriculture, prices, social assistance, remittance, etc.

Table 1 — T-Test for descriptives

	Control	Treated	Diff
Ethnicity of HH Head	3.640	3.626	0.014
Gender of HH head	0.362	0.411	-0.049***
Age of HH head	50.209	50.481	-0.273*
HH head's age squared	2724.643	2741.258	-16.615
Marital Status of HH head	0.663	0.701	-0.038***
Household Size	4.952	4.784	0.168***
Household Size Squared	29.772	28.402	1.370***
Distance to market	7.230	6.723	0.507***

3.1.1 Measure of Farm Productivity

In this study, we use total farm income per land used for farming for each household as a measure of farm productivity. The survey collects prices of all the produce on the ward level at the time of the survey, and also the amount of production for each household, which allows us to calculate the farm productivity measure. Farm income in our study includes the total production used for consumption and selling and also the income from livestocks. The primary reason behind including livestocks is because it is one of the largest non-land assest in the portfolio of rural households. And also the marginal cost of acquiring new livestock is cheaper due to pre- existing fixed cost investment and is important factor to consider when analysing the impact of remittance (Fafchamps, Udry, and Czukas 1998). So this farm productivity measure incorporates both the household decision making and also the structural transformation in this sector. We log transform the resulting farm productivity measure which allows us to deal with skewness and also makes the interpretation of relationship as elasticities. We also show the resutls using inverser hyperbolic transformation to show the robustness to transformation.

3.1.2 Measure of Remittances

Houshold remittances in our study is the total cash recieved annually from migrants through both formal and informal sources. It includes national and international receipts since both internal and international migration is prominent in Nepal. And the migrants in our study are all the members of the family who have migrated for any reason but are economically linked to the family. The remittances are then log transformed for the same reason as above.

3.2. Google Finance

For the data on exchange rate, firstly we get the daily exchange rate data from google finance and monthly exchange rate data from OANDA. To ensure that the exchange rate varies at the household level we get the average annual exchange rate one year prior to the interview date of household. Since the interview takes place in different times, we get variation in exchange rate even for the same destination. Since the correlation between the exchange rate between the google finance and OANDA was 0.99, we chose google finance data since it daily exchange rate. We use the NPR equivalent for all of the destination currencies.

3.3. Modified Mercalli Intensity (MMI)

For the exogenous measure of intensity of earthquake we use the data from US Geological Survey (USGS) which provides the data for Modified Mercalli Intensity (MMI)(USGS 2015). We specifically use spatial MMI map generated by USGS for the earthquake of April 2015[1]. The major reason

1. USGS (2015) has a detailed overview page for this earthquake under name 'M 7.8 - 67 km NNE of Bharatpur, Nepal'

for choosing MMI is because MMI measures the intensity of shaking at a location on the surface, whereas popular units like Richter Scale are magnitude scales that measure the force of earthquake which doesnot always translate to shaking intensity. We use this localized measure of intensity to calculate a MMI measure at the centroid of each ward.

4 — Empirical Strategy

We use a triple difference estimator to estimate the effect of remittances on farm productivity post earthquake on earthquake affected areas. We estimate the following:

$$\begin{aligned} Y_{hta} = & \beta_0 + \beta_1 Post_t + \beta_2 Treat_a + \beta_3 R_{hta} + \\ & \beta_4 (Post_t \cdot Treat_a) + \beta_5 (Post_t \cdot R_{hta}) + \beta_6 (Treat_a \cdot R_{hta}) \\ & + \beta_7 (Post_t \cdot Treat_a \cdot R_{hta}) + \gamma_a + \varepsilon_{hta} \end{aligned} \tag{1}$$

where Y_{hta} is the outcome for household h in time t and area a. $Post_t$ is a dummy variable which takes value 1 for post earthquake time. $Treat_a$ is a dummy variable which takes value 1 if the household is in earthquake affected area. R_{hta} indicates annular remittances received by household h in time t and area a. γ_a captures Ward fixed effects. Ward are the lowest administrative level and VDC are a level up from wards. We cluster the erros at the distric level (which is a level up from VDC) allowing for any arbitrary correlation in erros across a district (Bertrand, Duflo, and Mullainathan 2004).

β_7 is our coefficient of interest. Based on the potential outcomes framework (Robins 1986; Robins 1987), this coefficient compares the differences between the change in potential outcomes for households across the spectrum of remittance levels in earthquake-affected areas, before and after the earthquake and the change in potential outcomes for households across the spectrum of remittance levels in unaffected areas, before and after the earthquake. Essentially, it reflects the impact of remittances on outcome on eartquake affected areas. The key identifying assumption in this apporach is that in the absence of the earthquake, the difference in potential outcomes between remittance-receiving and non-remittance-receiving households would have evolved similarly in affected and unaffected areas.

However, the parallel trends assumtpions needed for the triple difference strategy might not hold due to the endogeniety of remittances. Remittances might be directed to more productive areas, or households with more skilled members might have both higher remittances and farm productivity. So, the triple difference coefficent might be biased alogside violating parallel trends assumption. To deal with the endogeniety of remittances, we use exchange rate as an instrument for remittances. We use two-stage least square method for estimation. To estimate this using observed data, we use:

First Stage:

$$R_{hta} = \alpha_0 + \alpha_1 \mathrm{E}_{hta} + \alpha_2 X + \phi_a + \eta_{hta} \tag{2}$$

where R_{hta} indicates annular remittances received by household h in time t and area a. E_{hta} indicates the average exchange rate for household h in time t and area a , ϕ_a captures Ward fixed effects. We cluster the erros at the distric level allowing for any arbitrary correlation in erros across district.

Second Stage:

$$\begin{aligned} Y_{hta} = &\beta_0 + \beta_1 Post_t + \beta_2 Treat_a + \beta_3 \hat{R}_{hta} + \\ &\beta_4 (Post_t \cdot Treat_a) + \beta_5 (Post_t \cdot \hat{R}_{hta}) + \beta_6 (Treat_a \cdot \hat{R}_{hta}) \\ &+ \beta_7 (Post_t \cdot Treat_a \cdot \hat{R}_{hta}) + \gamma_a + \varepsilon_{hta} \end{aligned} \tag{3}$$

where $\hat{R}_{hta}$ is the predicted remittances from first stage and everything else remains same as in Equation (1). However, one thing to note is that β_7 in equation (3) identifies the local-average-treatment-effect (LATE) (Imbens and Angrist 1994). In another laguage, it identifies complier average causal effect (CACE) which is the causal estimate of remittances on the households that received remittances induced by change in exchange rate. In our context, However, we do not think this is a big concern because of of the nature of international migration in Nepal which is different from other countries. Typically, migrantion from Nepal is temporary and the employment contract including length of employment, wages and in most cases even employer is arranged before the departure (Shrestha 2019) [2]. So, these estimate should be generalizable to remittance receiveing households.

2. Shrestha (2019, p. 3) provides a detailed explanation on how the migration from Nepal works

5 — Results

5.1. Threat to Identification

The goal of our paper is to estimate the causal effect of remittances on farm productivity for households under pressure from natural disaster. We use triple difference estimator to estimate this effect and instrument remittances using exchange rate. The threat to identification for our empirical strategy is if exchange rate is not excludable from equation (1) and does not explain the endogenous variable, remittances in our case. In IV literature, it is called the relevance and exclusion restriction assumption.

Our instrument exchange rate is determined at an international level, and in the context of nepal, Nepalase Rupee (NPR) is pegged with the Indian Currency (INR) at the rate of NPR 1.6 ĪNR 1 since 1994. Therefore, even when there is substantial increase in remittance inflows, the primary goal of the central bank is is to maintain the peg. As explained in section (3), the exchange rate in our dataset varies at the household level. Therefore one household's exposure to exchange rate is unlikely to affect another's, which makes exchange rate exogenous to households. One likely threat however is a potential spillover if remittances lead to investement in shared resources like irrigation systems but it is likely to hold at a broad level, and given that the context of the study is during the time of earthquake it is even more likely to hold. A favorable exchange rate should never decrease remittances for any household and vice versa. And due to the nature of labor migration in Nepal as discussed earlier, it is unlikely that some households would systematically reduce remittances when exchange rate when exchange rate becomes more favourable, which allows us to validly estimate the complier average causal effect (CACE). As for exclusion restriction, the potential violation is if household produce export crops and exchange rate directly affects their profitability. Another possible violation is through the changes in input costs. If households rely heavily on imported inputs for farming, exchange rate could affect production costs. However, this is unlikely to be the case firstly because of the peg with indian currency which is unchanged during the timeframe of this analysis and that the primary source of imports is from India. And also because the majority of the households are small holder subsistence farmers. Also the inclusion of household level controls and ward fixed effects captures captures any local level variations in input costs or access to inputs, local level market effects that might correlate with remittances and farm productivity and local geographical and climate conditions which might be correlated with propensity to receive remittances. It should also address for any possible spillover effects, because these are likely to occur within these small administrative units.

The another important aspect of the instrument is it's relevance, which can be directly tested. Although 3 implies that we are using multiple instrument, we firstly we look at the first stage of exchange rate on remittances to understand the nature of relationship. Table 2 shows a strong first stage estimates. It shows that the estimate is extremly stable to the inclusion of controls and fixed effects. If exchange rate were correlated with ommited variables that also affect remittances, we would expect the coefficient to change substantially when controls and fixed effects are added, however our result provides evidence to the exogeneity of exchange rate. This also further enhances the relevance of the instrument because the relatioship is uniform accross different household and locations. The Anderson-Rubin wald test rejects the null, meaning that the estimates are robust to weak instruments.

Another threat to identification is if in the absence of earthquake the potential outcomes of earthquake affected and unaffected areas would not follow the same trend. This cannot be tested directly, but can be assessed using pre trends and falsification exercise. Since, the household survey is limited to 2011 and 2016-2018, it is not possible to verify pre trends. However, we use satellite data at VDC level to test for the pre trends. For this we use Net Primary Production estimates from MODIS tool, which is a satellite based measure (Running and Zhao 2021), and has been used in various studies (Amirapu, Clots-Figueras, and Rud 2022; Zhao, Currit, and Samson 2011; Blakeslee et al. 2023). Figure (A1) shows that the pre trends for both treatment and control group are similar. To ensure the validity of the data from satellite based measure, we compare it to the district level agricultural productivity based on the administrative data from the department of agriculture, and they seem to conincide. But it is important to note that pre trends are neither necessary nor sufficient condition for parallel trends assumption (Roth et al. 2023). Following the literature, we also show the event study plots using the same data in figure (A2). Both, pre trends and event study provide evidence for parallel trends pre earthquake. We further run a falsification exercise to show that treatment assignment has no impact on pre-treatment outcomes in table (A3) using both OLS and IV estimator. In Table (A4) we show that treatment assignment is not correalated with any of the pre treatment household characteristics under VDC fixed effects. This is also probably why the pre-trends and event study plots suport the parallel trends. Following Imbens and Xu (2024), we further assess the overlap of the treament assignment using propensity scores in Figure (A3). We find that although the distribution of household affected by earthquake differ from those not affected, the propensity scores fall within the support. In Section 5.2, we further show evidence of robustness through sensitivity analysis.

Table 2 — First Stage Regression

	log(Remittances)	log(Remittances)	log(Remittances)
Exchange Rate	0.160***	0.162***	0.162***
	(0.022)	(0.022)	(0.023)
Adjusted R^2	0.163	0.171	0.232
Observations	31,859	31,856	31,856
F-statistics	53	24	21
VDC FE	No	No	Yes
Controls	No	Yes	Yes

Notes. In parentheses standard error clustered at district level. Statistical Significance: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable is log transformed remittance. Control variables include household head's ethnicity, gender, age, marital status, household size, household size squared, average annual rainfall, area of ward, poverty index of ward in 2011 census, population of ward, average number of month when agriculture is suitable.

5.2. Results

We interpret column 3 of Table (3) as our main specification. The first stage regression for all the intruments is provided in Table A5. All the intruments are statistically significant and have a strong first stage, and also reject the null of Anderson-Rubin wald test, which makes us confident that it is robust to weak intruments. To analyse the sensitivity of our results, we run same specification with inverse hyperbolic sine transformation for the dependent and independent variable and also with MMI as a continuous varible in Table (A6). The estimates do not change with IHS transformation and the estimate for continuous MMI remain qualitatively similar. In our case, we dont find that the treatment assignment is correlated with any pre treatment household characteristics under VDC fixed effects. However, the two way fixed effects estimators can be biased if there exists any kind of heterogeneity with respect to covariates (Ghanem, Sant'Anna, and Wüthrich 2024; Sant'Anna and Zhao 2020). We show that our result is not sensitive to estimator. We run inverse probability weighted (IPW) regression as suggested by Abadie (2005), in which the wieghts are based on Horvitz and Thompson (1952). Sant'Anna and Zhao (2020) show these wrights could be problematic when there are overlap problems and recommend normailizing Horvitz-Thompson weights like Hájek (1971). Although the overlap in our study is fine, we still run IPW regression with these normalized weights. The estimates still remain close to our main specification. This gives us confidence in interpreting the results.

Table 3 — Main Regression

	log(Productivity)	log(Productivity)
2016 - 2018 × Remittances × Treated	-0.186**	-0.168**
	(0.079)	(0.076)
2016 × Remittances × Treated	-0.206**	-0.181**
	(0.091)	(0.085)
2017 × Remittances × Treated	-0.226***	-0.200**
	(0.084)	(0.080)
2018 × Remittances × Treated	-0.132	-0.107
	(0.080)	(0.076)
Observations	31,859	31,856
VDC FE	Yes	Yes
Controls	No	Yes

Notes. In parentheses standard error clustered at district level. Statistical Significance: *** $p<0.01$, ** $p<0.05$, * $p<0.10$. Dependent variable is log transformed farm productivity measure. Control variables include household head's ethnicity, gender, age, marital status, household size, household size squared, average annual rainfall, area of ward, poverty index of ward in 2011 census, population of ward, average number of month when agriculture is suitable.

We find that a 10% increase in remittances decreases the farm productivity by 1.5% for households that are affected by earthquake. To learn the nature of our estimate we run various subsamples. First we run the same specification with only including year 2016, then 2016 and 2017.

We see that the average effect remains consistent with different sample but the effect slightly increases when including 2017 sample and then reduces when including 2018 sample. We further analyse the treatment effects for each year in Table (3). The treatment effect is statistically significant for 2016 and 2017, but the effect dissapears in 2018. It is consistent with the results of Table (3).

The overall effects are driven by the short term effects of the first two year. The disappering of the effect in the third year is also consistent with the event study plots in Figure (A2). This can be explained by the implementation of Agricultural Development Strategy (2015-2035), which was delayed due to the earthquake and was implemented starting from 2018 with establishment of Joint Sector Review (JSR) mechanism (GoN 2015, 2023).

6 — Mechanisms

We expect the mechanism through which remittances affect farm productivity to be different than in the normal situation. It is likely that due to earthquake there are shift in priorities. And these shift in priorities are extremely sensitive to how much resource households have. In the case of no resource constraint the negative impact of remittances on farm productivity could be driven by the income effect, which increase consumption, moral hazard, internal migration to urban areas. But, if the households are resource constrained, remittances has to be prioritized to absorbing the shock from earthquake. Therefore, we firstly try to identify if the households are resource constrained or not. For that, we use the same specification but consumption as an outcome. In a normal situation there are evidences that remittances increase household expenditures on food and clothing (Mishra, Kondratjeva, and Shively 2022; Mobarak, Sharif, and Shrestha 2023; Mergo 2016; Shrestha 2017; Kinnan, Wang, and Wang 2018; Clemens and Tiongson 2017) In Table (A9), we see that the expenditure on food consumption per week per household memeber and monthly utility expenditure per household on telephone, mobile phone, internet and cable TV has decreased in response to remittances. This is an indication that the households might be under resource constraints. Table (A11) shows the impact on direct expenditure on farming the expenditure on renting equipments has decreased but, expenditure on seed, fertilizer, irrigation and hiring is statistically insignificant. However, the point estimate are negative apart from hiring expenditure. We then further look at the impact on saving and borrowing behaviour in Table (A12), we see that the total loan amount are significantly down, however loan repaid is also down although it is significant at 10% significance level. However, number of loans and savings are statistically insignificant. It is an indication that remittances are used to replace the need for additional debt. This is in line with the literature (Gallagher and Hartley 2017; Yang and Choi 2007, 2007). We then look at land resources of households in Table (A16). We see that these are not changes in land owned and land used. Another interesting behvariour we see is in labour supply per adult in Table (A13). Overall for remittances result in decreased labour supply across all the domains which supports the moral hazard mechanism as shown by (Azam and Gubert 2006). Remittance receving households in earthquake affected area however on overall have not decreased their labour supply but have significantly decreased working for wage jobs in agriculture. This is however expected since the overall demand for labour in agriculture can be reduced in the short run. Overall, the mechanism for decresed farm productivity due to remittances seems to be driven by resource constraints, forcing households to use remittances to dampen the losses caused by earthquake. But, it also shows a clear evidence that remittances receving households are in a unique position as they can afford to do so. And this effects seems to be larger in the short run.

7 — Conclusion

This study provides novel insights into the impact of remittances on farm productivity in the aftermath of a major natural disaster, specifically the 2015 earthquake in Nepal. Our findings reveal that a 10% increase in remittances leads to a 1.5% decrease in farm productivity for households affected by the earthquake. This effect is particularly pronounced in the short term, with significant impacts observed in 2016 and 2017, but dissipating by 2018.

Our analysis suggests that the negative impact of remittances on farm productivity is primarily driven by resource constraints faced by affected households. In the wake of the earthquake, remittance-receiving households appear to prioritize immediate recovery needs over agricultural investments. This is evidenced by decreased expenditure on food consumption, utilities, and farming equipment rentals, as well as reduced borrowing, indicating that remittances are being used to replace the need for additional debt.

Our results highlight the role of remittances in disaster recovery. While remittances provide crucial financial support to affected households, allowing them to dampen the immediate economic losses caused by the earthquake, they also lead to short-term reductions in agricultural productivity. This finding shows the potential trade-offs between immediate disaster relief and longer-term economic activities in remittance-dependent economies.

The disappearance of the negative effect on farm productivity by 2018 coincides with the implementation of Nepal's Agricultural Development Strategy (2015-2035), suggesting that targeted agricultural policies may help mitigate the negative impacts of remittances on farm productivity in post-disaster contexts.

These findings have important implications for policymakers in remittance-dependent countries prone to natural disasters. They suggest a need for integrated approaches that leverage remittances for immediate disaster relief while also providing support to maintain agricultural productivity. Further it also unravels that households not receving remittances might be in even greater pressure and financial constrains and can put them into a poverty trap.

However, this study has limitations. First, while we establish a causal relationship between remittances and farm productivity post-earthquake, the exact mechanisms driving this relationship require further investigation. Second, our analysis focuses on the short to medium-term impacts; longer-term studies could provide insights into persistence of these effects and potential recovery trajectories.

In conclusion, this study contributes to our understanding of the complex interplay between remittances, natural disasters, and agricultural productivity. It highlights the need for policies that can harness the positive aspects of remittances for disaster recovery while mitigating potential negative impacts on key economic sectors like agriculture. Further, this highlights that private assistance is not a substiture to public assistance. Strengthing public assistance is therefore of paramount importance, and focusing on intervention to protect agricultural production is of great importance.

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A — Appendix

Table A1 — Main Regression: All Interactions Included

	log(Productivity)	log(Productivity)
Remittances × Treated × Post	-0.186**	-0.168**
	(0.079)	(0.076)
Treated × Post	0.563	0.139
	(0.847)	(0.819)
Remittances × Treated	0.120	0.106
	(0.078)	(0.075)
Remittances × Post	0.062	0.051
	(0.056)	(0.059)
Post	-0.126	0.487
	(0.569)	(0.617)
Remittances	-0.049	-0.042
	(0.057)	(0.061)
Observations	31,859	31,856
VDC FE	Yes	Yes
HH Controls	No	Yes

Note: In parentheses standard error clustered at district level. Statistical Significance: *** $p<0.01$, ** $p<0.05$, * $p<0.10$. Dependent variable is log transformed farm productivity measure. Control variables include household head's ethnicity, gender, age, age squared, marital status, household size, household size squared and distance to market.

Table A2 — Main Specification with different overlaps

	District Overlap			VDC Overlap		
	(1)	(2)	(3)	(4)	(5)	(6)
Remittances × Treated × Post	-0.176	-0.128	-0.128	-0.513	-0.429	-0.281
	(0.170)	(0.100)	(0.107)	(0.331)	(0.340)	(0.365)
Observations	28,414	28,414	28,407	5,132	5,132	5,131
District FE	Yes			Yes		
VDC FE		Yes			Yes	
Ward FE			Yes			Yes
HH Controls	Yes	Yes	Yes	Yes	Yes	Yes

Note: In parentheses standard error clustered at district level. Statistical Significance: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable is log transformed farm productivity measure. Control variables include household head's ethnicity, gender, age, age squared, marital status, household size, household size squared and distance to market. First three specifications include only districts that are present in both surveys. Last three specifications only include VDC's that are present in both surveys.

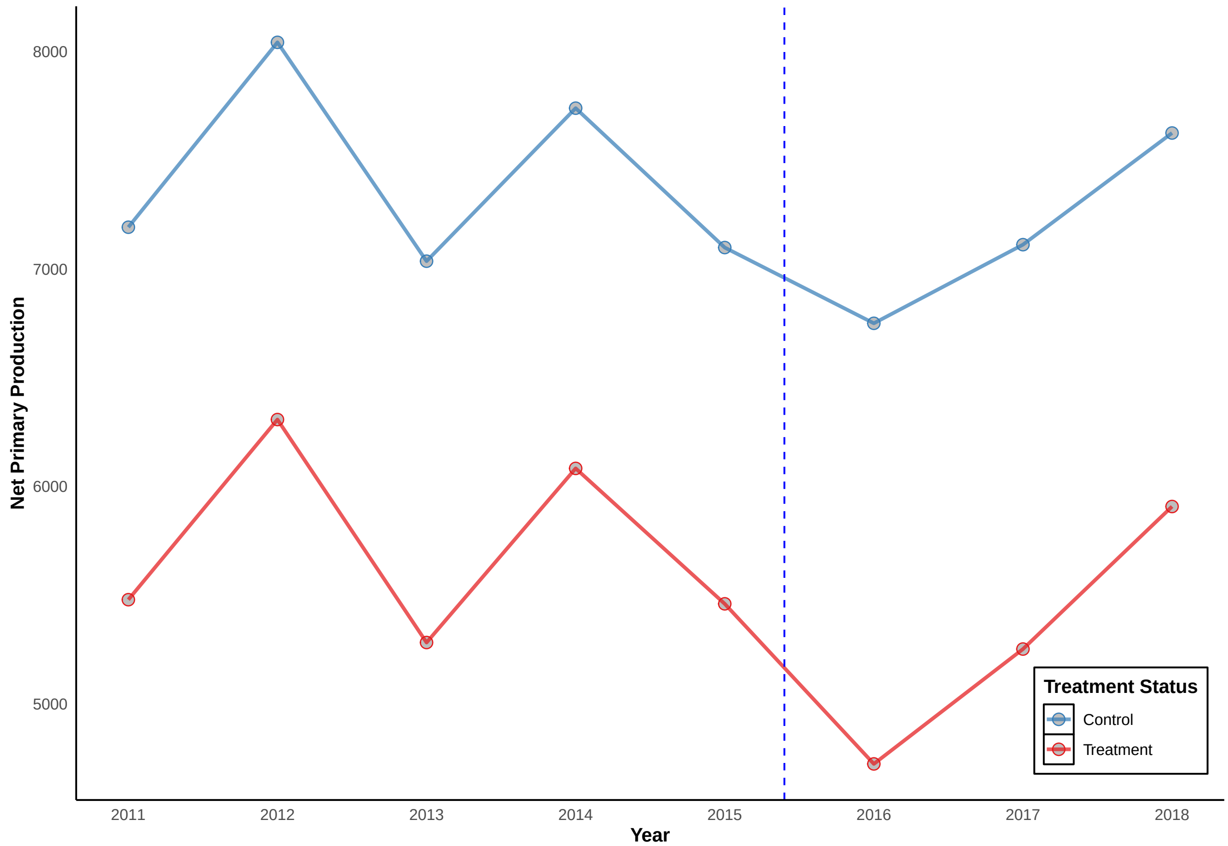

Figure A1 — Assessing pretrends of agricultural productivity

Note: This figure shows the trend of agricultural productivity for treatment and control areas

Source: MODIS tool and authors' calculations

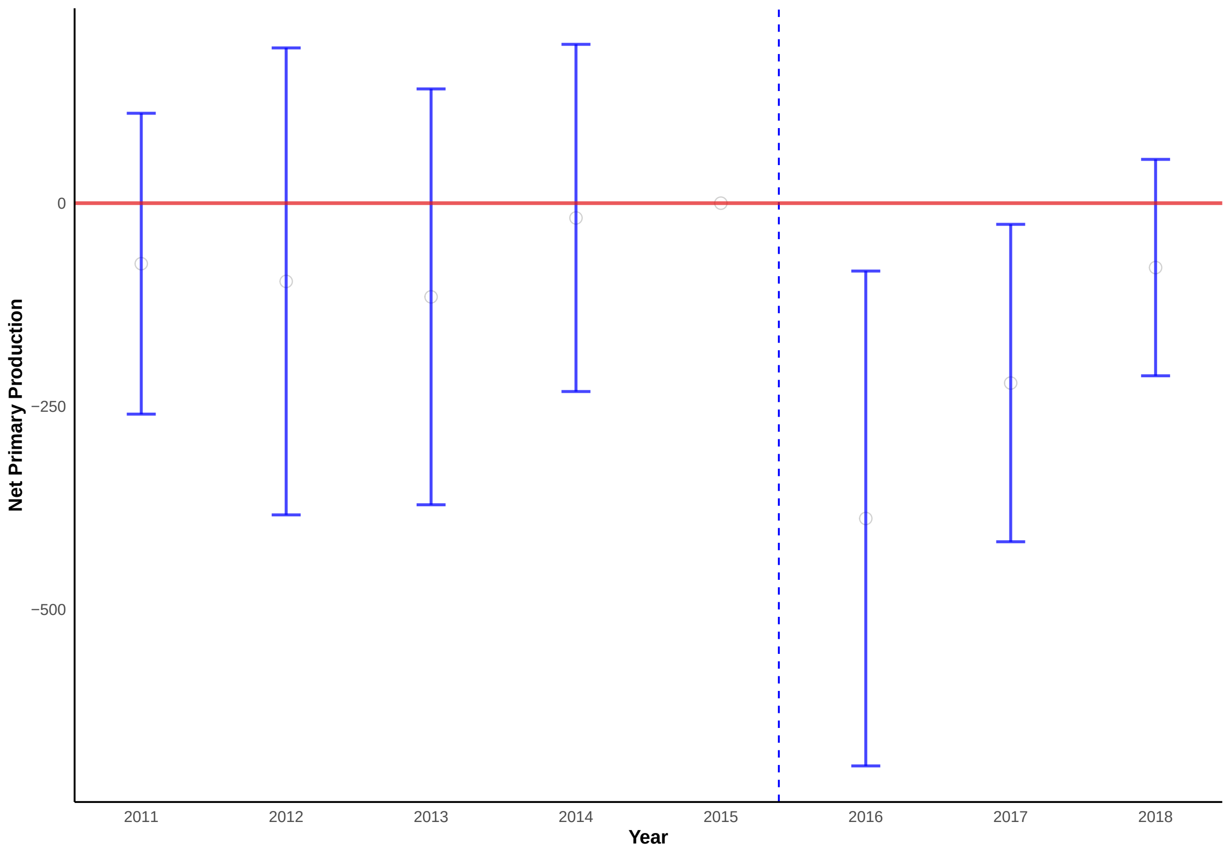

Figure A2 — Event Study Plot

Note: This figure shows the event study of earthqukae on farm productivity

Source: MODIS tool and authors' calculations

Table A3 — Placebo Test

	OLS	IV
	log(productivity)	log(productivity)
Treated	0.165	-0.367
	(0.459)	(0.606)
Remittances	0.017	0.005
	(0.015)	(0.051)
Treated × Remittances	-0.018	0.070
	(0.020)	(0.068)
Observations	10,818	10,552
VDC FE	Yes	Yes
HH Controls	Yes	Yes

Note: In parentheses standard error clustered at district level. Statistical Significance: *** p<0.01, ** p<0.05, * p<0.10. It uses only pre-treatment data. Dependent variable is log transformed farm productivity measure. Control variables include household head's ethnicity, gender, age, age squared, marital status, household size, household size squared and distance to market.

Table A4 — Regression of individual covariates on treatment assignment (Pretreatment)

	Treatment Dummy								
HH head is Chettri	0.007								
	(0.007)								
HH head is Brahmin	0.009								
	(0.005)								
HH head is Newar	-0.008								
	(0.008)								
Higher Caste		0.006							
		(0.005)							
HH head is Female			-0.004*						
			(0.002)						
Age of HH				-0.000					
				(0.000)					
Age Squared					-0.000				
					(0.000)				
HH is married						0.004			
						(0.006)			
Household Size							-0.001		
							(0.001)		
HH Size Squared								-0.000	
								(0.000)	
Distance to market									-0.000
									(0.000)
Constant	0.549***	0.549***	0.554***	0.557***	0.554***	0.548***	0.558***	0.554***	0.521***

Note: In parentheses standard error clustered at district level. Statistical Significance: *** p<0.01, ** p<0.05, * p<0.10. It uses pre-treatment data. The dependent variable is a treatment dummy which is equal to 1 for above median MMI.

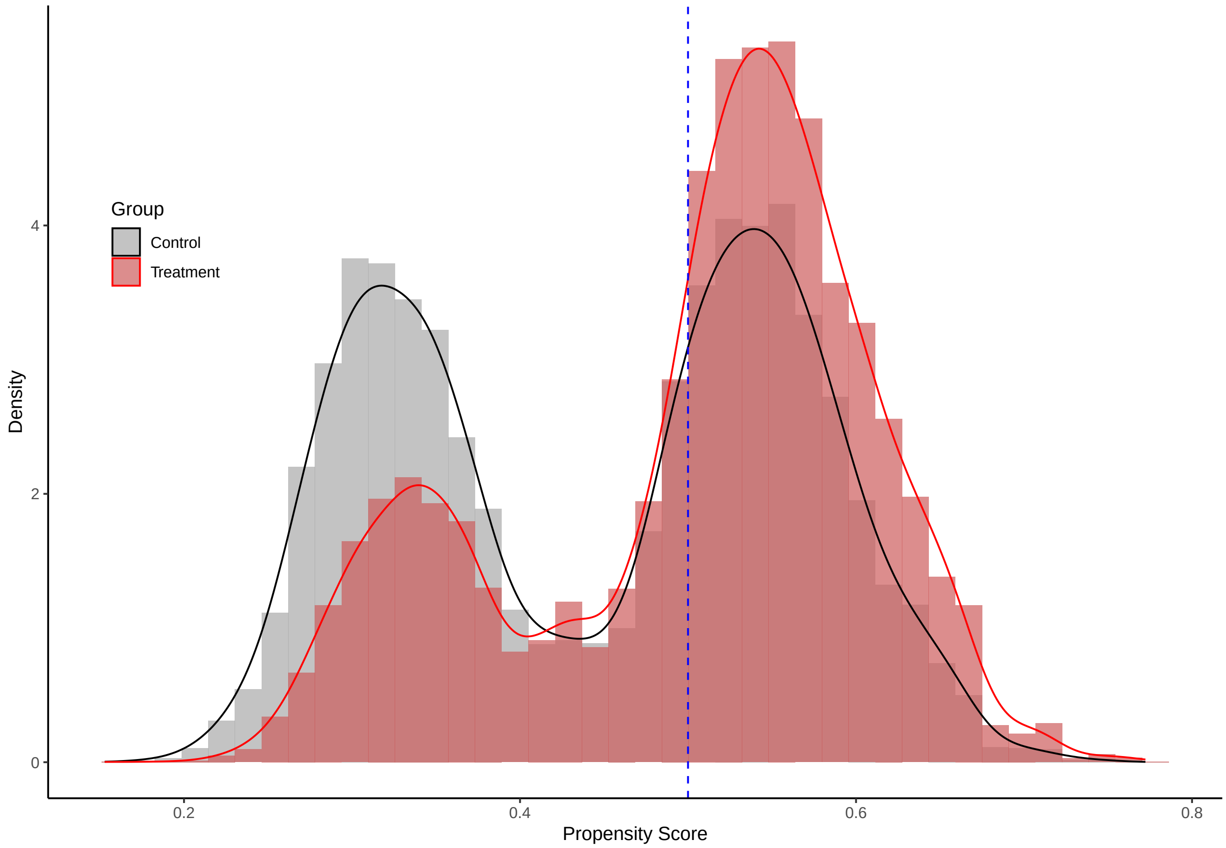

Figure A3 — Assessing Overlap using propensity scores

Note: This figure shows the overlap of propensity scores for treatment and control groups.

Source: Authors' calculations

Table A5 — First Stage Regression

	Remittances	R × Treatment	R × Post	R × Treatment × Post
Exchange Rate	0.069***	0.001	0.001	0.000
	(0.006)	(0.004)	(0.005)	(0.003)
Exchange Rate × Treatment	-0.018***	0.050***	-0.000	0.000
	(0.007)	(0.005)	(0.005)	(0.003)
Exchange Rate × Post	0.154***	-0.001	0.222***	-0.000
	(0.007)	(0.005)	(0.005)	(0.003)
Exchange Rate × Treatment × Post	0.047***	0.202***	0.029***	0.252***
	(0.009)	(0.006)	(0.007)	(0.004)
Ward FE				
HH Controls				

Note: In parentheses standard error clustered at district level. Statistical Significance: *** $p<0.01$, ** $p<0.05$, * $p<0.10$. Remmitances and R denote log transformed remittance. Control variables include household head's ethnicity, gender, age, age squared, marital status, household size, household size squared and distance to market.

Table A6 — Robustness of Main Regression

	log(Productivity)				ihs(Productivity)
	(1)	(2)	(3)	(4)	(5)
Normal_Remittance × Treated × Post	-2951.278***				
	(1099.693)				
Normal_Remittance × MMI × Post		-891.139**			
		(420.950)			
log(Remittances) × Treated × Post			-0.162**		
			(0.077)		
log(Remittances) × MMI × Post				-0.051**	
				(0.025)	
ihs(Remittances) × Treated × Post					-0.148***
					(0.050)
Observations	31,856	31,856	31,856	31,856	31,856
VDC FE	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes

Note: In parentheses standard error clustered at district level. Statistical Significance: *** p<0.01, ** p<0.05, * p<0.10. First specification uses standardized remittances. Second is our main specification. Third speficication uses IHS transformation of both dependend and independent variable. Fourth specification uses continouous MMI variable. Control variables include household head's ethnicity, gender, age, age squared, marital status, household size, household size squared and distance to market.

Table A7 — Main Regression: Different Fixed Effects

	log(Productivity)	log(Productivity)	log(Productivity)
Panel A: Aggregate			
Remittances × Treated × Post	-0.246*	-0.162**	-0.143*
	(0.127)	(0.077)	(0.074)
Panel B: Yearly Estimates			
2016 × Remittances × Treated	-0.256*	-0.176**	-0.164*
	(0.138)	(0.085)	(0.083)
2017 × Remittances × Treated	-0.283**	-0.194**	-0.180**
	(0.128)	(0.082)	(0.081)
2018 × Remittances × Treated	-0.184	-0.101	-0.087
	(0.124)	(0.077)	(0.075)
Observations	31,856	31,856	31,849
District FE	Yes		
VDC FE		Yes	
Ward FE			Yes

Table A8 — IPW regression

	log(Productivity)		
	(1)	(2)	(3)
Remittances × Treated × Post	-0.143*	-0.133	-0.126
	(0.074)	(0.083)	(0.081)
Observations	31,849	31,695	31,695
Ward FE	Yes	Yes	Yes
HH Controls	Yes	Yes	Yes

Note: In parentheses standard error clustered at district level. Statistical Significance: *** p<0.01, ** p<0.05, * p<0.10. The dependent variable is log transformed productivity measure. First specification is unweighted specification. Second specification uses weights based on (Abadie 2005). Third speficication uses normalized weights based on (Hájek 1971). Control variables include household head's ethnicity, gender, age, age squared, marital status, household size, household size squared and distance to market.

Table A9 — Consumption

	Total	HI	Food	Durable	Apparel	Utility	Fuel
Panel A: Aggregate							
Remittances × Treated × Post	-0.132	-0.042	-0.053	-0.143	0.003	-0.021	-0.064
	(0.089)	(0.222)	(0.035)	(0.095)	(0.055)	(0.106)	(0.052)
Panel B: Yearly Estimates							
2016 × Remittances × Treated	-0.120	-0.046	-0.044	-0.128	0.014	-0.025	-0.065
	(0.086)	(0.216)	(0.030)	(0.093)	(0.055)	(0.102)	(0.056)
2017 × Remittances × Treated	-0.124	0.030	-0.037	-0.146	0.008	-0.005	-0.076
	(0.086)	(0.231)	(0.030)	(0.093)	(0.053)	(0.103)	(0.057)
2018 × Remittances × Treated	-0.128	-0.057	-0.046	-0.134	0.010	0.001	-0.045
	(0.085)	(0.216)	(0.031)	(0.092)	(0.058)	(0.103)	(0.055)
Observations	31,856	31,856	31,856	31,856	31,856	31,856	31,856
VDC FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
HH Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: In parentheses standard error clustered at district level. Statistical Significance: *** $p<0.01$, ** $p<0.05$, * $p<0.10$. The dependent variable is log transformed measures of various categories of consumption expenditure. Control variables include household head's ethnicity, gender, age, age squared, marital status, household size, household size squared and distance to market.

Table A10 — Food Consumption

	Staple	Milk	Veg	Fruit	Meat
Panel A: Aggregate					
Remittances × Treated × Post	-0.035	-0.046	-0.038	-0.147	-0.010
	(0.025)	(0.073)	(0.035)	(0.100)	(0.103)
Panel B: Yearly Estimates					
2016 × Remittances × Treated	-0.025	-0.025	-0.026	-0.130	-0.041
	(0.021)	(0.079)	(0.031)	(0.106)	(0.106)
2017 × Remittances × Treated	-0.019	-0.044	-0.014	-0.138	-0.016
	(0.021)	(0.073)	(0.030)	(0.096)	(0.104)
2018 × Remittances × Treated	-0.028	-0.042	-0.036	-0.160	0.038
	(0.021)	(0.068)	(0.031)	(0.103)	(0.108)
Observations	31,856	31,856	31,856	31,856	31,856
VDC FE	Yes	Yes	Yes	Yes	Yes
HH Controls	Yes	Yes	Yes	Yes	Yes

Note: In parentheses standard error clustered at district level. Statistical Significance: *** $p<0.01$, ** $p<0.05$, * $p<0.10$. The dependent variable is log transformed measures of various categories of food consumption expenditure. Control variables include household head's ethnicity, gender, age, age squared, marital status, household size, household size squared and distance to market.

Table A11—Farm Input Expenditure

	Total	Seed	Fertilizer	Irrigation	Hire	Equipment Rent
Panel A: Aggregate						
Remittances × Treated × Post	-0.168**	-0.190**	-0.129	-0.062	0.092	-0.118
	(0.084)	(0.083)	(0.095)	(0.060)	(0.080)	(0.082)
Panel B: Yearly Estimates						
2016 × Remittances × Treated	-0.214***	-0.169*	-0.162*	-0.047	0.084	-0.147
	(0.080)	(0.090)	(0.091)	(0.055)	(0.079)	(0.092)
2017 × Remittances × Treated	-0.134	-0.173**	-0.123	-0.066	0.120	-0.051
	(0.086)	(0.080)	(0.088)	(0.067)	(0.087)	(0.078)
2018 × Remittances × Treated	-0.117	-0.211**	-0.066	-0.071	0.099	-0.137
	(0.095)	(0.090)	(0.112)	(0.065)	(0.086)	(0.089)
Observations	31,856	31,856	31,856	31,856	31,856	31,856
VDC FE	Yes	Yes	Yes	Yes	Yes	Yes
HH Controls	Yes	Yes	Yes	Yes	Yes	Yes

Note: In parentheses standard error clustered at district level. Statistical Significance: *** p<0.01, ** p<0.05, * p<0.10. The dependent variable is log transformed measures of various categories of agricultural expenditure per land used. Control variables include household head's ethnicity, gender, age, age squared, marital status, household size, household size squared and distance to market.

Table A12 — Financial Outcomes

	Loan Amount	Loan Repaid	Savings	Financial Position
Panel A: Aggregate				
Remittances × Treated × Post	0.104	0.079	-0.096	-0.637
	(0.253)	(0.163)	(0.227)	(0.578)
Panel B: Yearly Estimates				
2016 × Remittances × Treated	0.085	0.062	-0.159	-0.662
	(0.249)	(0.159)	(0.233)	(0.562)
2017 × Remittances × Treated	0.126	0.035	-0.036	-0.620
	(0.247)	(0.156)	(0.236)	(0.584)
2018 × Remittances × Treated	0.087	0.104	-0.090	-0.601
	(0.260)	(0.164)	(0.227)	(0.592)
Observations	31,849	31,849	31,849	31,849
Ward FE	Yes	Yes	Yes	Yes
HH Controls	Yes	Yes	Yes	Yes

Note: In parentheses standard error clustered at district level. Statistical Significance: *** $p<0.01$, ** $p<0.05$, * $p<0.10$. The dependent variable are log transformed measures of loan amount, loan repaid, savings amount and IHS transformed Savings - Borrowing value. Control variables include household head's ethnicity, gender, age, age squared, marital status, household size, household size squared and distance to market.

Table A13 — Household Labour Hours

	Total LH	Total Agriculture	Self Agriculture	Wage Agriculture
Panel A: Aggregate				
Remittances × Treated × Post	0.177	-0.140**	-0.123**	-0.114***
	(0.217)	(0.059)	(0.059)	(0.030)
Panel B: Yearly Estimates				
2016 × Remittances × Treated	0.161	-0.138**	-0.115**	-0.127***
	(0.216)	(0.057)	(0.057)	(0.032)
2017 × Remittances × Treated	0.194	-0.149**	-0.138**	-0.097***
	(0.217)	(0.062)	(0.062)	(0.034)
2018 × Remittances × Treated	0.176	-0.139**	-0.122*	-0.123***
	(0.217)	(0.063)	(0.064)	(0.032)
Observations	31,856	31,856	31,856	31,856
VDC FE	Yes	Yes	Yes	Yes
HH Controls	Yes	Yes	Yes	Yes

Note: In parentheses standard error clustered at district level. Statistical Significance: *** $p<0.01$, ** $p<0.05$, * $p<0.10$. The dependent variable is log transformed measures of total labour hours per year per head and subsequent categorization of sector of labour supply namely; self agriculture, self non-agricultural, wage agriculture, wage non-agriculture. Control variables include household head's ethnicity, gender, age, age squared, marital status, household size, household size squared and distance to market.

Table A14 — Labour Hours Individual

	Total LH	Total Agriculture	Self Agriculture	Wage Agriculture
	(1)	(2)	(3)	(4)
Panel A: Aggregate				
Remittances × Treated × Post	0.084	0.010	0.012	-0.039*
	(0.105)	(0.080)	(0.082)	(0.023)
Panel B: Yearly Estimates				
2016 × Remittances × Treated	0.047	-0.014	-0.006	-0.047*
	(0.102)	(0.075)	(0.078)	(0.024)
2017 × Remittances × Treated	0.113	0.015	0.014	-0.028
	(0.106)	(0.083)	(0.083)	(0.024)
2018 × Remittances × Treated	0.085	0.021	0.021	-0.041*
	(0.112)	(0.095)	(0.098)	(0.024)
Observations	136,856	136,856	136,856	136,856
Ward FE	Yes	Yes	Yes	Yes
HH Controls	Yes	Yes	Yes	Yes

Note: In parentheses standard error clustered at district level. Statistical Significance: *** p<0.01, ** p<0.05, * p<0.10. It is based on individual level dataset. The dependent variable is log transformed measures of total labour hours per year and subsequent categorization of sector of labour supply namely; self agriculture, self non-agricultural, wage agriculture, wage non-agriculture. Control variables include household head's ethnicity, gender, age, age squared, marital status, household size, household size squared and distance to market.

Table A15 — Labour Hours Individual (Intensive Margin)

	Total LH	Total Agriculture	Self Agriculture	Wage Agriculture
	(1)	(2)	(3)	(4)
Panel A: Aggregate				
Remittances × Treated × Post	0.044	-0.033	-0.028	-0.069*
	(0.033)	(0.082)	(0.087)	(0.037)
Panel B: Yearly Estimates				
2016 × Remittances × Treated	0.060*	0.006	0.017	-0.083**
	(0.034)	(0.084)	(0.092)	(0.039)
2017 × Remittances × Treated	0.063*	-0.048	-0.048	-0.049
	(0.037)	(0.090)	(0.093)	(0.040)
2018 × Remittances × Treated	0.008	-0.061	-0.054	-0.081**
	(0.039)	(0.089)	(0.095)	(0.039)
Observations	74,491	74,491	74,491	74,491
Ward FE	Yes	Yes	Yes	Yes
HH Controls	Yes	Yes	Yes	Yes

Note: In parentheses standard error clustered at district level. Statistical Significance: *** $p<0.01$, ** $p<0.05$, * $p<0.10$. It is based on individual level dataset. The dependent variable is log transformed measures of total labour hours per year and subsequent categorization of sector of labour supply namely; self agriculture, self non-agricultural, wage agriculture, wage non-agriculture. Control variables include household head's ethnicity, gender, age, age squared, marital status, household size, household size squared and distance to market.

Table A16 — Land

	Land Owned (hectare)	Land Used for Agriculture	Share of Upland	Share of Land Irrigated
Panel A: Aggregate				
Remittances × Treated × Post	-0.070	0.009	-0.024***	-0.012*
	(0.249)	(0.033)	(0.008)	(0.006)
Panel B: Yearly Estimates				
2016 × Remittances × Treated	-0.103	0.005	-0.026***	-0.012*
	(0.254)	(0.033)	(0.008)	(0.007)
2017 × Remittances × Treated	-0.082	0.011	-0.026***	-0.013*
	(0.248)	(0.033)	(0.009)	(0.007)
2018 × Remittances × Treated	-0.017	0.013	-0.021**	-0.010
	(0.242)	(0.033)	(0.009)	(0.006)
Observations	30,602	30,602	30,559	30,602
Ward FE	Yes	Yes	Yes	Yes
HH Controls	Yes	Yes	Yes	Yes

Note: In parentheses standard error clustered at district level. Statistical Significance: *** $p<0.01$, ** $p<0.05$, * $p<0.10$. The dependent variable is log transformed measures of total land owned per head, total land used for agriculture per head, share of upland, share of land irrigated. Control variables include household head's ethnicity, gender, age, age squared, marital status, household size, household size squared and distance to market.