Heterogeneous Effects of Migration and Remittances on Migrant-Sending Agricultural Communities: The Case of Southern Ethiopia,

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Abstract

Using household survey data, the paper empirically evaluates the heterogeneous effects of migration and remittances on migrant-sending communities in southern Ethiopia. A multi-stage stratified sampling procedure was used to select sample villages from each survey area and households from each sample unit. To account for several econometric issues and consistently estimate the impacts of migration and remittances, the study adopted a three-stage least-squares method complemented with endogeneity and multicollinearity test. The findings of the paper reveal that the migration of labor out of agriculture has a significant negative effect on a household's adoption of different agricultural technologies, as well as crop yield. By contrast, the remittances sent by migrants partially compensate for the lost-labor deficit, leading to increased use of modern agricultural inputs and crop yield. Besides, it's observed that the adoption of different agricultural technology is invariant to the migrants' gender. Overall, the return of migration suggests that the adoption of modern agricultural technologies and crop yield in migrant-sending communities are found to be higher after migration participation, though the impacts vary for households with different production conditions.

Keywords: Migration, remittances, agricultural technology, crop yield, gender, Ethiopia

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Introduction

In contrast to the early 1990s, when the severe civil war pushed numerous Ethiopians outward, recent migration out of agriculture has increased as agrarians in the rural areas of Ethiopia struggle to reconcile livelihood degradation and high unemployment rates. Internal conflicts are also increasing and income inequality and rural poverty are high. In addition, extreme climate variability and recurrent droughts are becoming more severe and frequent, which adversely affect the lives and livelihoods of the poor farmers who mainly depend on subsistence rain-fed agriculture (Hunnes, 2012; Kuschminder, Andersson, & Siegel, 2013; McLeman & Smit, 2006). Rural households are pursuing off-farming employment and thus, migration has been an important strategy to respond to the negative environmental extremes.

With incomplete labor markets, however, the migration of the working labor force has reduced labor input in local agricultural production (De Brauw, Huang, Rozelle, Zhang, & Zhang, 2002; Mendola, 2008). Traditional Ethiopian agriculture would be more responsive to a reduction in available farm labor as it was featured as a labor-intensive production. Further, the impact of migration on agricultural production varies depending on the migrants' gender as rural male and female laborers often engaged in different agricultural activities. If male and female laborers are not perfect substitutes for these activities, migration may have different opportunity costs for both male and female migrants Pfeiffer & Taylor, 2008).

Conversely, the remittances sent by migrants play an essential role in Ethiopian agricultural production. Since capital markets and other economic institutions are underdeveloped in rural Ethiopia, migrant remittances can set the motion in development dynamics by lessening production and investment constraints faced by households and creating income linkages (E. J. Taylor, 1999; J. E. Taylor, 2001; Xu, 2008). Migrant remittances are beneficial to foster agriculture production, rises income, and improve general rural conditions (Cederström, 1990). Moreover, remittances support technological improvement in rural areas, enabling households to invest in modern agricultural inputs Durand, Kandel, Parrado, & Massey, 1996; Massey, Alarcon, & Durand, 1987; Stark, 1991).

By applying insights from the new economics of labor migration (NELM) theory to Ethiopia's migration, this paper aims to answer the following research questions. (1) When migrants leave the household, does the reduction in available family labor lead to reduced agricultural production and technology adoption? (2) What impacts do remittances, if any, have on agricultural production and the adoption of agricultural technologies? (3) Does the migrants' gender affect the impact of migration on the adoption of different agricultural technologies, as well as crop yield?

The motivation to understand the nexus between migration and the agricultural community is interesting for the following reasons. Mixed farming remains a primary source of household income for rural communities in southern Ethiopia. The return from agricultural activities is the main source of liquidity (de Brauw, 2014). If the household in general faces constraints against investing in crop production and high-yield technologies, the migration of some family members is more likely to occur with the expectation thatremittances will enable the household toovercome capital constraints and offer a positive gain in income in the case of crop failure (Quinn, 2009). However, as Ethiopian agricultural production is characterized by labor-intensive and subsistence nature, increases in labor migration may have a detrimental effect on the rural economy. It's argued that crop productivity and agricultural technology adoption is not likely to be equal for households with and with no migration.

As expected, the findings of the study reveal that the migration of the working labor force reduced the adoption of modern agricultural technologies and crop yield. In particular, the adoption of improved seed varieties, fertilizer, and chemical use, the area applied to row planting, and *Teff* yield sharply fall when migrants leave the household. By contrast, remittances generated from migration partially offset the negative effects induced by out-migration and led to increased agricultural technology adoption and crop yield. The findings of the study also suggest that the migrants' gender does not affect the impact of migration on agricultural technology adoption, implying that there is no heterogeneous effects between male and female migrants. Alternatively, female migrants would be beneficial in terms of remittances, as the adoption of modern agricultural technologies and crop yield in source households, were found to be higher after the migration decision.

The rest of the paper is organized as follows: section 2 describes the linkage between migration, remittances, and agricultural production in Ethiopia. Section 3 specifies the econometric methods used in the empirical study. In this section, the paper also addresses the data and econometric methods used to estimate the parameters. Section 4 reports empirical findings with a discussion of policy implications. Section 5 concludes the paper.

Migration, Remittances, and Agricultural Production in Ethiopia

International migration from Ethiopia is a recently emerged phenomenon. It is thought to be the 1970s revolution has driven the largest refugee outflows in the history of the country, though a few urban royal familieshad been migrating for advanced education to the Western countries during the imperial periods. Nowadays, Ethiopia is witnessed with a large-scale migration of working labor forces in search of better opportunities outside the country. Since 2015, it is estimated that about two million Ethiopians (2% of the population) resided outside their country Carter & Rohwerder, 2016). Between the years 2008 and 2013, about 460,000 Ethiopians migrated to the United States, Israel, Canada, Europe, the Middle East, and other African countries Kuschminder et al., 2013).

The increase in migration has led to growth in international remittances consequently becoming the largest source of foreign exchange for Ethiopia. It has been witnessed that the flow of remittances has increased from 0.436 billion US$ in 2010 to 1.796 billion US$ in 2014 noting that a substantial amount of remittances are channeled through informal transfer systems. The percentage share of remittances to GDP also increased from 1.46% in 2010 to 3.23% in 2014. According to the World Bank development indicator, the flow of remittances to Ethiopia was the second largest, behind foreign direct investment, source of external financial inflows. However, due to the combined effects of the current economic downturn, fierce civil war, and severe ethnic tensions, the flow of remittances to Ethiopia is estimated to fall by about 77.5% in 2020 Fig

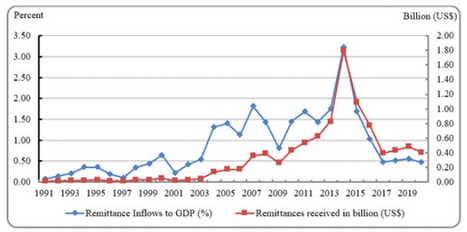

Fig 1 Received remittances and percentage share to GDP for Ethiopia, 1991-2020. Source: World Bank Categories > International Data > Countries > Ethiopia

In an agriculture-based rural economy, migrants' remittance can play a vital role in improving household income with a wide range of other productive activities. Agriculture remains an essential sector of the economy, accounting for half of the GDP, 84% of exports and foreign exchange earnings, and employs over 83% of the labor force of the country (Berhanu & Poulton, 2014). However, the potential of the agricultural sector to bring economic transformation has been debated for many
years. As the second largest country in Africa, Ethiopia is experiencing rapid population growth and increasing small plots, a key challenge for the future development of agriculture and the sustainability of their living(Diao, Taffesse, Yu, & Pratt, 2010).

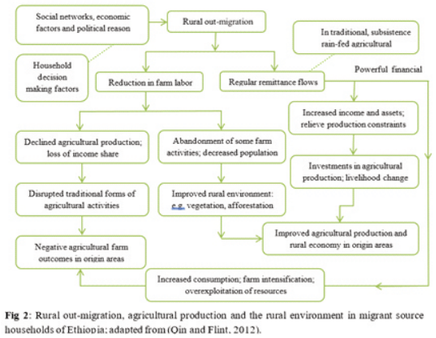

Fig 2: Rural out-migration, agricultural production and the rural environment in migrant source households of Ethiopia; adapted from (Oin and Flint, 2012).

A wide range of literature has revealed that the adoption of modern agricultural technologies is an important strategy to increase the productivity of smallholder agriculture in Africa (Doss, Mwangi, Verkuijl, & De Groote, 2003). However, the availability and access to credit in rural areas remain one of the major challenges Dupas & Robinson, 2009). In Ethiopia, recent studies revealed that 60- 80% of rural farmers are credit-constrained (Zewdie, 2015). Given this, poor rural households do not have or have limited access to modern inputs, and extending arable land is more feasible than using fertilizer or improved seed varieties (Losch, Fréguin-Gresh, & White, 2011). Moreover, many farmers do not have or have limited access to insurance markets.

This has contributed significantly to low yields experienced over the years. Based on the 2010 national survey, 40% of cereal production was linked to the use of fertilizer while 10% attributed to other inputs including irrigation (Diao et al., 2010).

However, despite the efforts made by policymakers to improve rural finance and economic institutions, rural communities in Ethiopia have experienced widespread migration and remittances. Previous studies have shown that earnings from international migrants have a positive impact on agricultural production and serve as a source of capital accumulation against risks and uncertainties (Lucas, 1987; Rozelle, Taylor, & DeBrauw, 1999). In recent years, the migration of labor out of agriculture is the fastest-growing component of off-farm employment in rural Ethiopia. Findings reveal that of the total farm households, 52.37% of them had at least one migrant and 39.42% have sent multiple migrants. Among the migrant-sending households, 87.46% had received average remittances of 167,183.5 ETB. In terms of gender, female laborers are relatively less likely to migrate than their male counterparts do Table 1.

Table 1. Migration prevalence, by sample regional villages (n = 548)

Variable mean	Total
Households with no migrants (%)	47.63
Households with migrants (%)	52.37
Households with single migrant (%)	12.95
Households with multiple migrants (%)	39.42
Share of female migrants (%)	26.74
Households receiving remittances (%)	87.46

Source: Authors' survey. Note: Means in this table are estimated at total sample households.

It's believed that migration trends in the villages of Southern Nations, Nationalities, and Peoples' Region in Ethiopia, where the household data for this study were collected, reflect the national trends. Due to their proximity to border countries, these villages have been migration hubs, providing more channels for human trafficking and smuggling. According to Ethiopia's 2021 Labor and Migration Survey, on average 25.6% of the labor force across rural areas of the Region had migrated to work elsewhere. Although the literature has a rich tradition on the socio-economic impacts of migration on source households, however, little is known about the heterogeneous effects of migration and remittances on migrant-sending agricultural communities, mainly from Ethiopia's agricultural production perspectives.

Moreover, the recent increases in labor migration from rural areas have raised social and economic concerns among policymakers. In a traditional agrarian economy deprived of complete labor markets, out-migration may induce local labor shortages, which in turn disrupted the traditional forms of local agricultural production. The adverse impacts

may be robust for labor-intensive crop production. By contrast, it's observed that remittances sent by migrants contribute to households' investment in agricultural technology adoption. Especially, the crop area planted with improved seed varieties, crop area applied to row planting arrangements, and crop yield were found to be higher in households with migration participation. Remittance-recipient households also spend more money on modern input use compared to households with no migration Table 2.

technology is defined as the proportion of crop area planted to improved seed varieties ; fertilizer use other chemical use (both herbicides and pesticides) ; and crop area applied to row planting So, the main equation explaining the adoption of agricultural technologies is expressed as:

$$T_A = \beta_{0A} + \beta_{1A}M + \beta_{2A}R + \beta_3 X_A + \varepsilon_A;\ A = s, f, c, p \quad (1)$$

The study also considers the productivity of *Teff* Y_C as a main outcome variable and modeled as:

$$Y_C = \gamma_0 + \gamma_1 M + \gamma_2 R + \gamma_3 X_y + \varepsilon_y \quad (2)$$

Table 2. Household-level Adoptions of Modern Agriculture Inputs and Crop Yield, By Migration Status

Variable description	Total samples (n = 548)	No migration (n = 261)	Migrants (n = 287)
Improved seed user households (%)	70.07	48.66	89.55
Area planted with improved seed varieties (ha)	0.998	0.881	1.105
Households that are fertilizer users (%)	72.26	53.26	88.26
Average fertilizer expenditure (ETB/ha)	2147.445	1908.812	2364.46
Households that are chemical users (%)	71.53	58.24	83.62
Average chemical expenditure (ETB/ha)	256.553	216.735	292.763
Households applied row planting of seeds (%)	44.16	40.07	48.66
Area applied to row planting arrangement (ha)	0.863	0.656	0.981
Average crop/*Teff* yield per unit area of land (kg)	1071.449	696.494	1412.436

Note: Means in this table are estimated at the individual level and the values are in Ethiopian Birr (ETB).

The competing results between households with migrants and non-migrants indicate several assumptions. First, migration reduced farm labor supply and negatively affects the adoption of modern inputs and crop yield in source households. This implies that the reduction in available farm labor, in turn, may lead to a reduction in agricultural technology adoption, as well as crop yield. By contrast, remittances sent by migrants are expected to offset the negative lost-labor

effects. Despite the differences between migrant and non-migrant households for some variables, other variables may confound descriptive analyses. The study applied empirical methods explained in the next sections to examine the nexus between migration, remittances, modern agricultural inputs, and crop yield while controlling the potential effect of confounding variables.

Econometric Methods and Data

f the adoption of high-yield technology is constrained and migration and remittances affect production constraints, then the constrained vector of technology adoption and crop yield depends on and . In addition, vectors of individual, household, and community characteristics denoted as and in equations (1) and (2), respectively influence households' decision to adopt modern inputs farm practices. Migration and remittances may have heterogeneous effects on outcome variables. The adoption of modern agricultural

It's assumed that the potential effect of migration is not always positive. The the decision to send out migrants can lead to the loss of human and financial capital in the origin areas which can potentially decline local agricultural production. The null hypotheses associated with NELM are, thus, keeping all explanatory variables constant, neither migration nor remittances affect the adoption of modern agricultural technologies H_0: β_1=0,β_2=0,∀ A against H_1: H_(0) is not true. The same holds for crop yield, equation (2). It is unlikely that all households sending out migrants receive remittances or not, all received remittances are invested in high-productivity technologies or related activities. Remittances are produced by allocating family members to migration; given migration, individual, household, and community factors W_R influences migrants to remit some amount of their income share
to their origin families:

$$R=\delta\_0+\delta\_1 M+\delta_2 \qquad W_R+\varepsilon_R \quad (3)$$

Migration a function of an individual, household, and village characteristics can also be represented in a count regression functional form as:

$$M = \exp(\alpha_0+\alpha_1 Z_M+\varepsilon_M) \quad (4)$$

Further, using the empirical model shown in equation (5), the study explored if the adoption of modern agricultural inputs and crop productivity varies with the migrant's gender. The key independent variable of interest is the migrants' gender; an interaction between the share of female migrants and the total number of migrants in a migrant-sending household (gen*M).

$$T_A=\beta_0+\beta_1 M+\beta_{(2)}(gen*M)+\beta_3 X_A+\varepsilon_A;\ A=s,f,c,p \quad (5)$$

Where T_A is the current outcome variable consisting of T_s, T_f, T_c, and T_p represents the proportion of the household's crop area planted with improved seed varieties, fertilizer use, chemical use, and row planting arrangements, respectively. The same holds for crop yield (productivity of *Teff*).

Estimation Methods and Issues

The statistical analyses of the household survey data are generally structured in four phases. First using descriptive analysis the paper described survey sample characteristics and aggregate patterns of household migration, adoption of modern inputs, and crop yield. Second, to estimate equation systems (1) through (5) consistently, the paper applied OLS with robust standard errors for remittances, equation (3), and a count functional form (Poisson regression) for migration, equation (4) and address several econometric issues. The functional form in equation (4) reflects that the number of migrants from a household will always be a non-negative integer. In the migration equation, factors besides non-negativity should also be taken into account. Many households do not send migrants, in the sample, 47.63% do not participate in migration. Meanwhile, 12.95% of migrant households send out more than one migrant. The study applies a count regression functional form to account for households that do not participate in migration and households with multiple migrants. Third, the paper empirically tests the migration and remittance hypotheses regarding the adoption of modern agricultural technology, as well as crop yield. To account for the statistical problems and unobserved characteristics of the household, the implications of the hypotheses are analyzed using three-stage least-squares (3SLS) methods. Fourth, the paper estimates if the impact of migration varies with the migrants' gender using two-stage least-squares (2SLS) methods.

The methodological challenge in estimating the impact of migration and remittances using observational studies is to construct a counterfactual situation against which the impact can be measured because of self-selection problems related to migration decisions and remittance recipients (Adams Jr, de Haas, & UO, 2012). The migration decision is observed for all households, while remittance receivers are only observed for households sending out migrants. Further complicating the estimation is migration and remittances are expected to be both endogenous concerning the adoption of modern agricultural inputs. Finally, migration, remittances, and adoption of modern inputs and technologies may be subject to a reverse causality which could cause simultaneous correlation issues across equations.

Due to limitations in the econometric dataset, the study relies on instrumental variables to identify the equation system and control many of the issues that arise from endogeneity and selectivity bias across equations (1) to (5). There are two vectors of instruments, for the remittances equation (3), and for the migration equation (4). The paper uses variables that explain the dependent variables they are instrumenting (migration and remittances in this case) but uncorrelated with the outcome variables such as modern input use and crop yield see e.g., (Atamanov & Van den Berg, 2012; Quinn, 2009; J. E. Taylor, Rozelle, & De Brauw, 2003).

It's assumed that in addition to the migrant's human capital and household characteristics, migration, , is a function of social migration networks and the percentage of the unemployment rate at a community level. The presence of a national community at the destination could drive migration by reducing the monetary and non-monetary cost of migration as well as enabling migrants to share information about jobs in other areas with their relatives and neighbors Hagen-Zanker & Siegel, 2007). Poor economic conditions in the origin communities (for instance, a high unemployment rate) may also drive migration. It is more likely that migration increases with the rate of unemployment in source communities (Sprenger, 2013). The study constructs a variable that assumes the value of one if a household in the village sends out a migrant in 1991 and zero otherwise, as proxy measures for migration networks. The economic condition of the sample villages was measured by the proportion of unemployment rate among households at the community level. It's hypothesized that migration networks and an unemployment rate at the village level affect the stock of migrants at the household level, but do not have a direct impact on household decisions regarding modern input use, as well as other farm activities.

Remittances are produced by allocating some family members to labor migration. Household characteristics and community-level variables also affect the amount and trend of remittance inflows. The study uses village-level variables, such as migrants' return (if households in the village experienced migrants' return for Ethiopian New Year) and married migrants (if households in the village had married migrants whose spouses and siblings are left behind) as an instrumental variables to predict remittances, received by the household. If migrants return home or intend to visit their families in the village during public holidays, they may bring ome share of their income to invest in land, housing, livestock, etc., and they may also bring some gifts in kind to build their reputation in source communities. A considerable amount of remittances is also sent back to the origin communities for exchange motives when married migrants from the village left their spouses and siblings behind in their home country. The transfers of money in the wider sense are paid to the household at home for services provided for childcare Hagen-Zanker & Siegel, 2007). This study assumes these village-level factors affect each household's remittance level but have no independent effect on household decisions regarding modern input use.

Finally, the correlation across equations is more likely to occur, as many of the decisions on migration, remittances, and adoption of modern agricultural technologies and inputs are made at the same time as other household decisions. Neither variable can be included as an exogenous variable in the main equations, (1) and (2). To determine the potential instantaneous covariance issues across equations the study applied iterated three-stage least-squares (3SLS) method. Under the same consideration, the gender equation specified as a reduced form in equation (5)is also estimated using both OLS and 2SLS methods.

Data and Variables

To establish the impacts of migration and remittances on agricultural technology adoption and crop yield, a multi-stage stratified sampling procedure was used to select 740 farm households from eight villages in southern Ethiopia. Data were collected between January and March 2022 and focused on agriculture, migration trends, topographic, and economic features of the study area. Eighth major *Teff*-growing villages distributed in three districts of the *Hadiya* zone located in the Southern Nations, Nationalities, and Peoples' Region of Ethiopia were graphed. Surveyed sample households are typically restricted to 548 due to incomplete data. Nearly all these households in the survey area engage in farming activities and grow *Teff* crops, while 70.07% of households adopt improved *Teff* varieties, 72.26% applied chemical fertilizer, 71.53% applied other agro-chemicals, and 44.16% plant improved *Teff* seeds in rows, see Table 2.

Migrants were identified from the household survey as family members who have left the household to work elsewhere for at least three months during the year before the survey time. Findings reveal that of the total sample, 52.37% of farm households had at least one migrant, and 26.74% of them were found to be female migrants. Among the migrant-sending communities, 87.46% of households had received remittances, see Table 1. It's believed that these variables capture many of the intrinsic economic and demographic differences between rural households, including the propensity for farmers to migrate and remit.

There are far more dimensions to agricultural technologies and crop yield to be dealt with here, but the study only focuses on four components of technologies and one crop yield identified as the main outcome variables for this study. The current outcome variables are identified as the adoption of improved seed varieties, fertilizer use, other chemical use, and crop area applied to rowplanting arrangements Table 3. The components of agricultural technologies were identified through the household survey

Table 3. Description of the outcome, explanatory, and instrumental variables (n = 548)

Variables	Definition of variables (unit)	Mean	Std. Dev.
Outcome Variables			
Improved seed varieties	The proportion of crop area planted to improved *Teff* varieties (ha)	0.998	1.019
Area of row planting	*Teff* area applied to row planting arrangement (ha)	0.551	0.599
Chemical usage	Herbicide/pesticide expenditure in the previous season (ETB/ha)	256.553	262.052
Fertilizer usage	Average fertilizer cost in the last agricultural season (ETB/ha)	2147.445	1807.726
Crop yield	The productivity of *Teff* crop per unit area of land (kg/ha)	1071.449	1027.762
Key independent variables			
# of migrants	# of labor migrants who left the household at least for three months	1.282	1.481
Gender of the migrant	The proportion/ratio of female migrants	0.267	0.390
Log value, remittances	Log value of remittances received by migrant households in ETB	12.023	0.438
Explanatory Variables in X			
Family size	The number of current family members in the household	6.262	2.332
Level of education	The education level of the household head in schooling years	6.104	3.382
Landholding size	Farmland operated by the household (ha)	1.599	1.028
Land quality	If the weighted average of land quality is high (yes = 1)	0.525	0.499
Livestock ownership	Livestock ownership in tropical livestock unit	6.430	2.369
Risk attitude	Farmer's willingness to accept risk (yes = 1)	0.680	0.466
Pests and diseases	Pests and diseases are key problems (yes = 1)	0.565	0.496
Instrumental variables for migration			
Migration networks	If a household in the village sends out a migrant in 1991 (yes = 1)	0.745	0.436
Unemployment	Average percentage share of unemployment rate at village level	7.478	4.697
Instrumental variables for remittances			
Migrants return	If households in the village had experienced a migrant return for Ethiopian New Year (yes = 1)	0.515	0.501
Married migrant	If households in the village had married migrants who left their spouse and siblings behind (yes = 1)	0.536	0.499

Source: Authors' survey.

and the empirical application of crop is *Teff*.

[…Teff is a fine grain—about the size of a poppy seed—that comes in a variety of colors, from white and red to dark brown. It is an ancient grain from Ethiopia, and comprises the staple grain of its cuisines].

The sample households report whether they have experienced the adoption of improved seed varieties and other complementary packages through *Teff* production. In defining the criteria for adoption, it is also important to consider how closely the farmers follow the sequential agronomic practices for the adoption of new technologies, and the rate and timing of fertilizer and chemical application have to fall within certain limits (CIMMYT, Maize, & Center, 1993; Doss et al., 2003; Jain, Arora, & Raju, 2009). In this case, *Teff* production accounts for about 88.7% of the total cereal crop production in the sample area. The average crop planted with improved *Teff* varieties is estimated to be 0.998 hectares and the average *Teff* yield is 1071.45 kg/ha, similar to that of the national average productivity, which is near 1 t/ha.

The survey also incorporated a wide range of other controlled explanatory variables that influence the adoption and choices of agricultural technology and crop productivity at household levels Table 3.

Ethics Statement

In the data collection process, the household survey was conducted anonymously. Research and Ethical clearance were obtained from the Ethiopian Civil Service University Research and Publication Coordination Office (Ref: RPCO/032/2014). Permission was granted from Local and Regional Authorities in Ethiopia. All research participants were adult heads of households. With the help of local development agents, surveying procedures were explained to each participant and verbal consent was obtained from all participants. An independent community member acted as a witness for the voluntary informed decision-making of participants to take part in the study. Ethics committees were aware that minors (under 18 years) would provide

their consent. Overall the data collection procedures and indeed the data analysis and depository were made anonymously in a way that prevents survey participants from being identified by name and number.

Results and Discussion

Estimating the Migration and Remittance Equations

The paper estimates equations (3) and (4) using OLS with robust standard errors and Poisson functional form, respectively Table 4. The predictions from the OLS and Poisson equations that enter the adoption of modern agricultural technology and crop productivity equations can be interpreted as the predicted number of migrants and remittances from a migrant household. Both specifications yield parameter estimates that are largely consistent with the expected effects of most of the instrumental and exogenous household variables on migration and remittances. All instruments are found to be valid and significantly affect migration and remittances.

The study results found that remittances are a positive function of migration. Each additional migrant is associated with a 3560.802 ETB increase in remittance income. Besides, households that faced crop shocks received more remittances from their migrant family members. The coefficients on migrants' return and married migrants were also found to be significant and positively associated with increased remittance inflows to source communities.

Another interesting finding is that the exogenous household characteristics affect migration and remittances in ways that are consistent with findings by other scholars Atamanov & Van den Berg, 2012; J. E. Taylor et al., 2003). For instance, households with larger family sizes, as well as households with a larger share of male adults are more likely to send migrants. However, wealthier households (measured as larger owners of farmland and livestock units) are less likely to send out migrants, indicating retaining the family labor would be more important. Village characteristics, such as migration networks and unemployment rate have positive and significant effects on migration decisions. Households in villages with strong migration networks and high unemployment rates are more likely to participate in migration.

Three-Stage Least-Squares (3SLS)

Many of the decisions about migration, remittances, and investment in new agricultural activities are usually made simultaneously at the household level as part of the livelihood strategy to maximize household income. Unobserved household characteristics that cause migration or remittances may also shape households' adoption of agricultural technologies. To identify the suspected endogenous variables, the study applied a direct test of endogeneity assumption for the suspected variables. The study also conducted an IV second-stage least squares (2SLS) regression for all systems of structural equations against all of the exogenous variables, including all of the instrument variables. Then the endogeneity results (Durbin-Wu-Hausman test) were estimated for both suspected endogenous variables. As expected, migration and remittances are found to be endogenous to all specifications of the outcome variables S1 Table.

To account for these endogeneity issues, the findings shown in Table 5 are estimated using a 3SLS method. The estimator performs reasonably well and the statistics for all the outcome variables are significantly different from zero. The instruments also pass the Hausman-Wu test for endogeneity, using the migration and remittances equations (3) and (4). In general, the results find some evidence to support both the migration and remittances hypotheses, though the coefficients on migration and remittances yield mixed results. The exogenous variables defined in the previous section also affect agricultural technology adoption and crop yield in ways that are consistent with findings by other similar studies.

Migration, Remittances, and Technology Adoption

The heterogeneous impacts of migration and remittances on agricultural technology adoption, as well as crop yield, are estimated using iterated 3SLS method Table 5. Overall, the results found statistically significant effects of migration and remittances on agricultural technology adoption and *Teff* yield, providing evidence in support of the key hypotheses of NELM. Specifically, the migration of labor out of agriculture has a negative and significant effect on the adoption of improved seed varieties. Holding other factors constant, the area applied to improved seed varieties sharply fall by 1.085 hectares Table 5. The possible explanation for the negative impact is associated with the

Table 4. Estimated Effects of Household and Village Characteristics on Migration and Remittances

Explanatory variables	Remittances OLS	Migration Poisson
Number of migrants sent out by the household	3560.802**	
	(2437.475)	
Current family size of the household	0.529	0.064***
	(0.435)	(0.042)
The share of male adults in the household	-0.133	0.018**
	(0.512)	(0.031)
Most educated in the household	0.243	-0.003
	(0.222)	(0.008)
Landholding size	-1.026	-0.031**
	(0.068)	(0.023)
Livestock ownership (TLU)	0.094	-0.005*
	(0.205)	(0.016)
Local wage labor in ETB	0.086	0.042
	(0.060)	(0.061)
Risk attitude	2.574*	0.062
	(1.044)	(0.053)
Number of summer crop shocks	0.842**	0.073
	(0.416)	(0.082)
Social migration networks, village level		1.671**
		(0.045)
The unemployment rate, village level		0.065**
		(0.013)
Migrants return for Ethiopian New Year, village level	42.826**	
	(6.426)	
Married migrants, village level	32.083**	
	(5.523)	
N	548	548
R^2	0.782	0.864
F	162.654	82.261

Note: Coefficients are presented with standard errors in parentheses. Whereas ***, **, and * denote the significance level at 1%, 5%, and 10%, respectively.

high labor demand for *Teff* production. Extensive land preparation, row planting, hand weeding, and the sequential agronomic practices of improved *Teff* production require a substantial amount of labor input.

Households that have migrated face high pressure to satisfy the labor demand and, therefore, may decide not to use the new varieties at a specific time than the household can provide.

The migration of labor out of the farm was found to be negatively related to the adoption of other complementary inputs and row-planting practices Table 5. The use of fertilizer and other chemical inputs falls significantly when migrants leave the household. Improved *Teff* seeds are planted in rows or straight lines, either singly or in multiple rows, mainly to enhance maximum yields and improve convenience for activities such as weeding, fertilizer application, chemical use, and harvesting. These farming practices consume more labor inputs and are negatively related to households sending out migrants. The fall of technology adoption caused by a large amount of labor withdrawal may influence the household to abandon labor-intensive new varieties and switch to conventional crop production or spend cash on labor-saving technologies.

Besides, the paper estimates the effects that migration and remittances have on the productivity of *Teff* Table 5. The direct impact of migration on *Teff* yield is found to be significant and negative. The productivity of *Teff* falls by 230.082 kg as members of the household leave the farm area to work elsewhere. These findings prove one of the predictions of the NELM model that, in theshort run, migration causes statistically significant lost-labor effects that decline agricultural productivity, particularly labor-intensive crops that are more responsive to the causal effects of labor migration.

On the other hand, the empirical results revealed that the negative impact induced by a reduction in family labor availability is partially compensated by the sums of remittances received by the migrant household. The remittances generated by migrants yield a positive and significant

Table 5. Estimated Effects of Migration and Remittances on Agricultural Technology Adoption and Teff Yield; Using Three-Stage Least-Squares (3SLS)

Explanatory variables	Improved seed varieties	Fertilizer Usage	Chemical usage	Area applied row planting	Crop yield (kg/ha)
	(1)	(2)	(3)	(4)	(5)
# of migrants, predicted	-1.085**	-985.005**	-335.608**	-0.093**	-230.082**
	(0.329)	(265.002)	(48.034)	(0.005)	(55.260)
Remittances, predicted	0.018***	0.876***	0.203**	0.003**	4.349*
	(0.033)	(0.308)	(0.059)	(0.002)	(1.097)
Log value, remittances	0.092***	0.842**	0.302**	0.102**	4.308**
	(0.025)	(0.283)	(0.052)	(0.021)	(1.302
Family size	0.006	6.806	3.926	0.003	-12.420
	(0.023)	(4.083)	(1.484)	(0.005)	(9.282)
Young dependents	-0.088*	-60.561*	-18.480*	-0.010	32.892
	(0.036)	(35.203)	(8.096)	(0.001)	(25.058)
Level of education	0.002	8.602	1.008	0.005**	8.007
	(0.001)	(4.664)	(0.086)	(0.001)	(6.731)
Landholding size	0.278*	61.502*	36.270*	0.262*	58.003*
	(0.023)	(10.830)	(7.903)	(0.060)	(8.470)
Land quality	0.003	0.088	22.660	0.006	28.804
	(0.040)	(0.070)	(15.040)	(0.020)	(6.010)
Livestock ownership	0.014	2.622	0.059	0.001	0.049
	(0.002)	(3.028)	(0.027)	(0.003)	(2.098)
Access to irrigation	0.002	12.148	1.360	0.006	9.678
	(0.040)	(7.405)	(0.908)	(0.020)	(2.027)
Labor cost	-0.020	-31.960	-8.072	-0.001	-8.085
	(0.008)	(23.032)	(3.012)	(0.010)	(2.098)
Risk attitude	0.083**	78.005**	32.027**	0.230**	39.203**
	(0.040)	(28.078)	(18.063)	(0.050)	(20.503)
Pests and diseases	-0.009	-27.006	-17.060	-0.005	-28.040
	(0.006)	(65.002)	(3.023)	(0.010)	(16.024)
N	548	548	548	548	548

Note: Coefficients are presented with standard errors in parentheses. Whereas ***, **, and * denote the significance level at 1%, 5%, and 10%, respectively.

impact on the adoption of improved seed varieties Table 5. Each ETB remitted by the migrants is associated with 0.018 hectares of additional *Teff* area planted with improved seed varieties. The coefficients on remittances were also found to be statistically significant and positively related to the use of inputs and row planting arrangements. An additional one ETB remitted by migrants is associated with 0.876 ETB increases in fertilizer expenditure, 0.203 ETB increases in other chemical expenditure and 0.003 hectares increase in crop area applied to row planting arrangements. Remittances have also a positive impact on the productivity of *Teff*. Each ETB remitted by migrants is associated with a 4.349 kg increase in crop yield.

Table 5 also reports estimates of the average response of agricultural technology adoption and yield to the elasticity change in remittances. The paper sees that the estimated coefficients of log value of remittances on agricultural technology adoption and crop yield are positive and statistically significant, suggesting that remittances can support technological improvement in rural areas and foster agricultural productivity. Quantitatively, a percentage increase in remittances is associated with 0.092 hectares increase in crop area applied to improved seed varieties, 0.842 ETB rises in fertilizer expenditure, 0.302 ETB increase in other chemical expenditure, 0.102 hectares increase in row planted area, and 4.308 kg increases in *Teff* yield. verall, the results found that losing farm laborers to migration reduces the adoption of modern agricultural technologiesand tighten the labor shortage for *Teff* production. While remittances sent by migrants relieved households' credit and risk constraints and enables them to engage in high-yield production activities.

Outcome Difference Due to the Migrants' Gender

Several academic studies have attempted to estimate the impact of migration on source communities Gubhaju & De Jong, 2009; Mergo, 2016; Pfeiffer & Taylor, 2008). However, few studies have made an effort on whether or not the migrants' gender affects the impact of migration on agricultural technology

adoption and crop yield. The differences in outcome due to the migrants' gender are likely to be non-probabilistic and, of course, few studies have successfully addressed the issues of gender associated with the adoption of labor-intensive technologies and crop yield, particularly in a country where female laborers are forced to work largely on non-productive household activities.

Over the past two decades, the face of migration in and from Ethiopia has been changing from a small number of political refugee flows to a gradual mass form of labor migrants. As rural females are deprived of productive resources and opportunities in Ethiopia, migration is the last-resort option for them to deal with these challenges. In addition, traditionally, female laborers are considered relatively less productive in on-farm activities and least favorite labor participants in farm areas than male laborers. In a majority of the rural areas of the country, they stay at home and spend their time on non-productive activities. In many respects, migration choice improves the independence and power of the poor rural female. If they take outside employment opportunities, they may have access to financial resources. So, the expected impact of male and female migrants in source families do not always coincide and the migrant's gender may affect the outcome variables differently.

Given that, the paper estimates the effects of the migrants' gender on the adoption of modern inputs and crop yield using the two-stage least-square method Table 7. The gender of the migrants is defined as the share of female migrants in the total number of migrants and created an interaction term between female migrants and the total number of migrants. The coefficient on the ratio of female migrants is, however, found to be statistically insignificant, but only for agricultural technology adoption.

Table 6. Estimated Impacts of Gender-Specific Migration on Agricultural Technology Adoption and Crop Yield; Using Two-Stage Least-Squares (2SLS)

Explanatory variables	Improved seed varieties	Fertilizer Usage	Chemical usage	Area of row planting	Crop yield (kg/ha)
	(1)	(2)	(3)	(4)	(5)
# of migrants, predicted	-1.058*	-782.325***	-124.476**	-1.804**	-642.562***
	(0.684)	(148.092)	(35.806)	(0.602)	(231.098)
Gender of the migrant	-0.016	-312.458	-28.804	-0.010	-142.081*
	(0.003)	(26.864)	(5.026)	(0.006)	(28.678)
Family size	0.002	8.082	3.098	0.008	-5.065
	(0.080)	(4.050)	(1.042)	(0.002)	(1.204)
Young dependents	-0.042**	-78.209*	-32.068*	-0.083	41.081*
	(0.003)	(16.014)	(8.320)	(0.027)	(12.571)
Level of education	0.009	5.085	0.089	0.005**	2.988
	(0.004)	(4.607)	(0.005)	(0.002)	(1.040)
Landholding size	0.284**	42.087***	35.078***	0.436*	78.258***
	(0.126)	(28.065)	(6.605)	(0.083)	(16.240)
Land quality	0.003	2.852	5.840	0.006	82.656
	(0.004)	(3.362)	(1.054)	(0.002)	(18.027)
Livestock ownership	0.003	2.809	0.011	0.028	0.108
	(0.001)	(3.032)	(0.049)	(0.016)	(0.091)
Access to irrigation	0.017	43.203	3.632	0.001	12.396
	(0.042)	(6.453)	(1.286)	(0.019)	(4.398)
Labor cost	-0.061	-23.580**	-7.033*	-0.002	-5.088
	(0.082)	(8.072)	(3.092)	(0.010)	(1.078)
Risk attitude	0.582***	8.003*	3.181**	0.338***	1.548**
	(0.061)	(3.901)	(1.075)	(0.136)	(1.297)
Pests and diseases	-0.028	-8.016	-5.869	-0.005	-1.879*
	(0.064)	(5.805)	(3.035)	(0.030)	(1.092)
N	548	548	548	548	548
R^2	0.635	0.529	0.536	0. 456	0.483
adj. R^2	0.580	0.472	0.340	0.397	0.462

Note: Coefficients are presented with standard errors in parentheses. Whereas ***, **, and * denote the significance level at 1%, 5%, and 10%, respectively.

Outcome variables, such as crop area applied to improved seed varieties and row planting practices and use of fertilizer and chemical inputs are invariant to the migrants' gender. By contrast, the coefficients on female migrants are found to be significant and negatively associated with crop yield. The insignificant relationship between female migrants and the use of modern inputs indicates that the migration of female labor out of a farm has less effect on the adoption of modern inputs and yield. This would be attributed to less involvement in productive activities. Much empirical work indicates that female household members are less likely to be involved in farm activities in Ethiopia. The absence of female laborers can lead to a labor gap and may force male laborers to work longer and harder in farm fields and might be obliged to take on household tasks that informally were assigned to female members of the household. Even though the impact of female migration remains insignificant on outcome variables, sending female laborers for a high-wage-earning job is cost-effective and beneficial for households in rural Ethiopia in terms of the overall impact of remittances sent by migrants.

Conclusion

This paper evaluates the heterogeneous impacts of migration and remittances on the adoption of modern agricultural technology and crop yield of the agricultural community in southern Ethiopia. Using household survey data, the paper empirically assesses the impacts of migration and remittances on agricultural technology adoption and crop yield via a 3SLS method. The findings of the study indicate that the direct impact of labor out-migration at the household level finds to be negative and significant. Specifically, the migration of labor out of agriculture leads to a significant negative effect on crop area applied to improved seed varieties and row planting arrangements, the use of fertilizer and other chemical inputs, and consequently crop yields.

The results also show that remittances can partially compensate for the negative impact induced by the reduction of family labor availability. Remittances sent by migrants yield a significant positive effect on the adoption of improved seed varieties, fertilizer use, chemical use, and the application of row planting arrangements, as well as crop yields. The overall impact of migration would suggest that the adoption of modern agricultural technology and the productivity of crops for a source household are higher after migration. The evidence argues that the impacts of migration and remittances on agricultural technology adoption might vary depending on crop production conditions and households' consideration of agriculture profitability. The results of this study are consistent with previous studies carried out in Mexico (Quinn, 2009), Bangladesh (Mendola, 2008), and China (Li, Wang, Segarra, & Nan, 2013).

Furthermore, the findings of this paper have important implications for agricultural development in Ethiopia and other low-income countries. To improve the adoption of modern technologies for staple food crops, special reforms are needed to address the shallow labor, credit, and insurance markets in rural areas. If the Ethiopian government needs to improve the stagnant agricultural productivity, it may call for policy interventions that can enhance the adoption of improved seed varieties and improve credit markets by reforming the formal and informal rural micro-finance institutions. Besides, the findings suggest some broader implications for development strategies available to Ethiopia. Effective government policies are needed to retain the migration of multiple laborers out of agriculture and ensure that youth remain socially and economically engaged and productive in the local agricultural economy.

Finally, this study is subject to some limitations. First, migration and its return may have complex impacts on migrant sending-households in Ethiopia. But, the paper only focuses on the heterogeneous impacts of migration and remittances on the adoption of agricultural technologies and crop yield in the case of *Teff* production. Future studies may assess a wider range of impacts of migration on Ethiopian agricultural production. Moreover, due to the limitation of the data set, the study relied on instrumental variables to identify the impact of migration on agricultural production. An identification method that can better control for unobserved heterogeneities may be required to further test the NELM hypotheses in respect of agricultural technology and crop yields.

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References

Adams Jr, R., de Haas, H., & UO, O. (2012). Migrant remittances and development: Research perspectives. *SSRC Web Anthology*, 1-132.

Atamanov, A., & Van den Berg, M. (2012). Heterogeneous effects of international migration and remittances on crop income: Evidence from the Kyrgyz Republic. *World Development, 40*(3), 620-630. doi: 10.1016/j.worlddev.2011.07.008

Berhanu, K., & Poulton, C. (2014). The political economy of agricultural extension policy in Ethiopia: economic growth and political control. *Development Policy Review, 32*(s2). doi: 10.1111/dpr.12082

Carter, B., & Rohwerder, B. (2016). Rapid fragility and migration assessment for Ethiopia. *Rapid Literature Review*.

Cederström, T. (1990). Migrant remittances and agricultural development. *Culture, Agriculture, Food and Environment, 11*(40), 2-7.

CIMMYT, Maize, I., & Center, W. I. (1993). The adoption of agricultural technology: a guide for survey design: CIMMYT.

de Brauw, A. (2014). Migration, youth, and agricultural productivity in Ethiopia. *International Food Policy Research Institute, Washington, DC*.

De Brauw, A., Huang, J., Rozelle, S., Zhang, L., & Zhang, Y. (2002). The evolution of China's rural labor markets during the reforms. *Journal of Comparative Economics, 30*(2), 329-353. doi: https://escholarship.org/uc/item/0676t97v

Diao, X., Taffesse, A. S., Yu, B., & Pratt, A. N. (2010). Economic importance of agriculture for sustainable development and poverty reduction: The case study of Ethiopia. Paper presented at the Global Forum on agriculture.

Doss, C. R., Mwangi, W., Verkuijl, H., & De Groote, H. (2003). Adoption of maize and wheat technologies in Eastern Africa: A synthesis of the findings of 22 case studies.

Dupas, P., & Robinson, J. (2009). Savings constraints and microenterprise development: Evidence from a field experiment in Kenya: National Bureau of Economic Research.

Durand, J., Kandel, W., Parrado, E. A., & Massey, D. S. (1996). International migration and development in Mexican communities. *Demography, 33*(2), 249-264.

Gubhaju, B., & De Jong, G. F. (2009). Individual versus household migration decision rules: Gender and marital status differences in intentions to migrate in South Africa. *International migration, 47*(1), 31-61. doi: 10.1111/j.1468-2435.2008.00496.x

Hagen-Zanker, J., & Siegel, M. (2007). The determinants of remittances: A review of the literature. doi: https://ssrn.com/abstract=1095719