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Impact of Rural Out-Migration on Agricultural Technology Adoption of Rural Households in Southern Ethiopia

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Abstract

Using the new economics labor migration theory as a theoretical framework and the multinomial treatment effects negative binomial regression as an analytical model in southern Ethiopia, this study investigated the effects of rural out-migration on the intensity of agricultural technology adoption. In the year 2021, data were collected from 415 sample houses using stratified random sampling. Regression analysis showed that while the influence of migration from rural to urban areas is negligible, participation in international migration greatly increases the likelihood of technology adoption in rural families by 38.9%. The intensity of agricultural technology adoption by rural households is negatively and significantly correlated with male-headed households and household age, while the frequency of extension visits, non-farm participation, saving, membership in cooperatives, sales of livestock, and tropical livestock unit are positively and significantly related to the intensity of agricultural technology adoption. The outcome is consistent with the labor migration theory's risk and credit hypotheses. To encourage the adoption of agricultural technology and stop the recent surge of rural out-migration in southern Ethiopia, policymakers should provide access to capital, public services, and viable off-farm employment in rural areas.

Keywords

Migration, self selection bias, negative binomial regression, technology adoption.

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Introduction

Migrants move from areas with limited economic activity to areas with better economic opportunities, and the primary cause of migration is the economic discrepancy between migrant-sending and migrant-receiving areas (World Bank, 2020). Between 2000 and 2019, the number of international migrants in the world increased from 174 to 272 million people (UNDESA, 2020). Between 2000 and 2019, the total amount of remittances from international migrants increased from 121.6 billion to 714.2 billion United State dollars in the world (UNCTAD, 2020). Further, about 77 percent of the remittance flow is directed to developing countries. Added to this, the number of internal migrants has been mounting and reached 1.3 billion in developing countries in 2016 (FAO, 2019).

Despite the continuous flow of labor from the rural agricultural sector to urban non-agricultural sectors and capital in the form of remittance from urban non-agricultural sectors to the rural agricultural sector, the impact of rural out-migration on agricultural technology adoption in migrant-sending origin areas is the source of debate (United Nations, 2016). Put differently, the impact of rural out-migration on agricultural technology adoption in migrant-sending rural areas is expected to be dichotomous. On the one hand, there is an optimistic view of rural out-migration which claims that rural out-migration promotes agricultural investment in migrant-sending rural areas through remittance (Stark,1985). On the other hand, there is a pessimistic view of rural out-migration which considers migration as a loss of human capital to migrant-sending origin areas (Rozelle et al. 1999; Lucas, 1987).

With an estimated 115 million population in 2020, Ethiopia is the second-most populous country in Africa, and the 12th in the world (World Bank, 2021). Both rural-urban and international migration have different patterns in Ethiopia under different political regimes (Adugna, 2021). First, during the emperor's regime (1941-1974), both rural-urban and international migration were insignificant in Ethiopia (Lyons, 2009), and only an estimated 20,000 people out-migrated to western countries primarily to get an education (Terrazas, 2007). Second, during the military government (1974-1991), international migration increased mainly due to political repression, civil war, and the mid-1980s famine in Ethiopia. But rural-urban migration was limited due to the restrictions on rural out-migration mainly through forced villagization (Alemu, 2005). Third, during the current government (1991 onwards), both rural-urban and international migration have been mounting in Ethiopia. While the percentage of rural-rural migrants decreased from 35.6 to 23.4, the percentage of rural-urban migrants increased from 21.6 to 32.2 between 1999 and 2021 (LMS, 2021). Regarding international migration, while the stock of international migrants increased from 611 thousand to 1.1 million people, the inflow of remittances increased from 53 to 404 million US dollars between the period 2000 and 2020 (World Bank, 2021). About 42, 26.9 and 25.6 percent of Ethiopian emigrants originated from rural areas of Oromia, Amhara, and SNNP regions respectively (LMS, 2021).

Regarding the destination of migrants, 30.7, 12.4, 8.9, and 8.3 percent of migrants from Ethiopia were directed to Saudi Arabia, South Africa, United Arab Emirates, and the United States respectively (LMS, 2021). Generally, international migrants from Ethiopia use three major migration corridors. First, the eastern corridor is the busiest route of migration, and Ethiopians migrate to the Middle East following this route since the 1990s. Most of the migrants who traveled following this path are young, female, and unmarried traveling mainly as houseworkers. Female migrants make near 95 percent of all formal migrants from Ethiopia in the Middle East (MoLSA, 2018). Second, Ethiopian migrants use the northern migration corridor only in rare cases to transit through Sudan to Libya and Europe (Massey et al., 1998). Third, the southern migration corridor runs from the Horn of Africa to South Africa. While Ethiopia and Somalia are the major sources of migrants to South Africa, Ethiopia alone accounts for two-thirds of the migrants (Horwood, 2009). Hadiya and Kembata from southern Ethiopia largely migrate to South Africa (Zewdu, 2015). The migration from Hadiya and Kembata-Tembaro zones to South Africa started in 2000 (Kanko et al., 2013). Though migration from these two zones to South Africa started in recent years, the level of outflow is very high, and more than 39.4 percent of rural households have at least one international migrant (Tsedeke and Ayele, 2017).

While few studies (Mendola, 2005; Williams, 2014; Shi, 2020; Sun et al., 2021) have examined the link between rural out-migration and technology adoption, they found mixed results, focused on the adoption of a single technology and not controlled for self-selection bias into migration. This study examined the impact of rural out-migration on the intensity of technology adoption using the new economics labor migration theory as a theoretical framework, and multinomial treatment effects negative binomial model as an analytical model. The rest of this study is organized as follows. The second section presents the literature review. The third section describes the materials and method. The fourth section presents results and discussion while the fifth section deals with the conclusion.

Literature review

Theoretical review

There are various theories of migration (Ravenstein, 1885; Lewis, 1954; Lee, 1966; Harris-Todaro, 1970; Stark, 1985) that predict the relationship between rural out-migration and agricultural technology in economic literature. Lewis's (1954) two-sectors migration theory insists that the withdrawal of labor from the rural agricultural sector to the urban industrial sector improves the productivity of both, and will lead to economic development. This theory assumes that there is a surplus of labor in the rural agricultural sector and a shortage of labor in the urban industrial sector. According to this theory, the rural areas of developing countries are characterized by smallholder farmers, rapid population growth, and low agricultural productivity. Hence, the transfer of labor from the agricultural sector to the urban industrial sector would improve production in receiving urban and sending rural areas (Ranis, 2003).

The human capital theory of migration (Harris and Todaro, 1970) primarily focuses on the causes, and impacts of rural out-migration on migrants and migrant-receiving urban areas. This theory claims that rural out-migration is primarily caused by wage differences between migrant-sending and receiving areas. According to the neoclassical theory of migration, migration decisions are made at an individual level. However, the new economics labor migration theory (Strak, 1985) primarily focuses on the impact of rural out-migration on migrant-sending rural areas, and this theory has shifted the unit of analysis from individual to household level in migration studies. This theory states that the limited access to insurance and credit services in rural areas is the primary cause of participation in rural out-migration. There are two hypotheses regarding the impact of rural out-migration on agricultural technology adoption by rural farmers; the risk hypothesis and the credit hypothesis. According to these two hypotheses, agricultural investment depends on both the level of risk aversion and the credit constraints of rural farm households. The risk and credit hypotheses state that rural out-migration increases the adoption of new agricultural technology by reducing the risk aversion and credit constraint of households. In other words, remittance from rural out-migration will not only be used for household consumption and rather but will also be used to finance the adoption of agricultural technologies by rural households (Stark, 1985).

On the one hand, the risk hypothesis assumes that rural out-migration is an important tool to ensure rural households against the risk of agricultural losses. In other words, if a rural household adopts agricultural technology and the crop fails, migrants will direct more remittances to households in the origin areas to cover the losses. Hence, the presence of a migrant member in the household will increase the likelihood of agricultural technology adoption even if the remittance is unobserved. Remittance is observed if and only if the household faces crop failure (Lucas and Stark, 1985; Tylor and Wyatt, 1996). Therefore, the risk hypothesis states that the number of migrants and the likelihood of agricultural technology adoption by rural farmers are positively correlated.

On the other hand, the credit hypothesis states that capital is a very scarce factor of production in rural areas and agricultural productivity and technology adoption depends on credit constraint. The adoption of new agricultural technology requires finance but the unbanked rural household faces liquidity constraints. This implies that remittance from migrants to migrant-sending households will increase the likelihood of new technology adoption by lessening the credit constraint of farmers. According to the credit hypothesis, ceteris paribus, remittance from migrants increases crop production efficiency and the likelihood of agricultural technology adoption by smallholder farmers. So, the household undertakes the migration of its members to get remittances and finance agricultural investments. The basic assumption of these hypotheses is that rural households are unbanked and unable to borrow money to finance their agricultural investments against future harvests (Tylor, 1999).

Besides, the new economics labor migration theory assumes that there are four motives of remittance from migrants namely; altruism, insurance contract, loan contract, and investment (Lucas and Stark, 1985). The altruism motive insists that migrants send remittances because they care about their families (Stark, 2009) while the insurance motive claims that migrants send remittances to protect their families against shocks (Rosenzweig and Stark, 1989). The loan contract motive claims that remittances are the repayment of informal loans which is taken by migrants from their family to enhance their human capital and finance the cost of migration. Finally, the investment motive argues that migrants send remittances to households in the origin areas to return and inherit the investment (Lucas, 1985). Therefore, the new economics labor migration theory assumes that the primary causes of rural out-migration are the lack of credit and insurance markets, and rural out-migration affects the technology adoption behavior of migrant-sending households by lessening the risk aversion level and credit constraint of households. This study applied the new economics labor migration theory as a theoretical framework

Empirical review

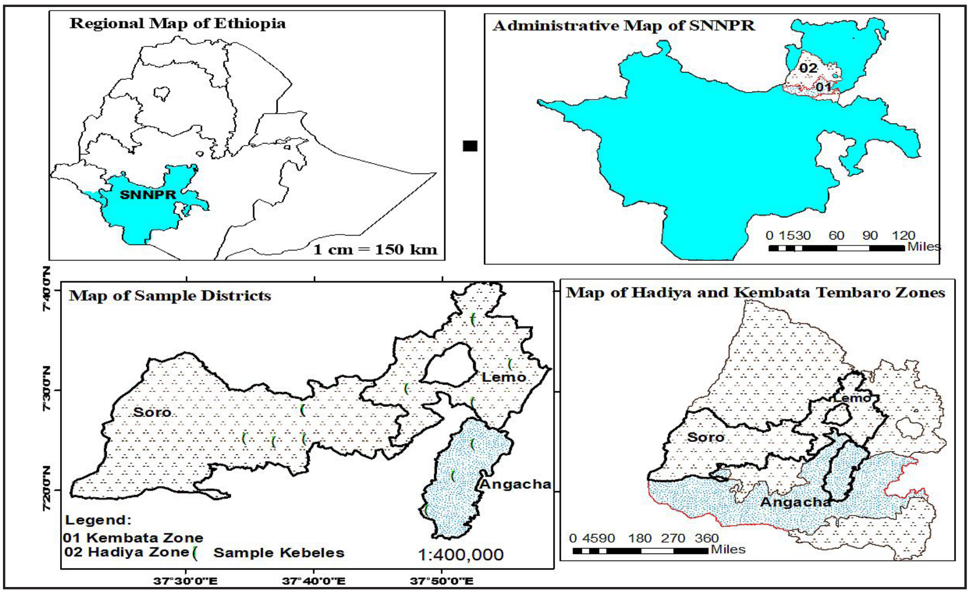
This section presents an empirical review of the impact of rural out-migration on agricultural technology adoption. The theoretical literature predicts that rural out-migration promotes agricultural technology adoption in origin areas by reducing the risk aversion level and the credit constraints of rural households. However, previous studies on the link between rural out-migration and agricultural technology adoption found mixed results. On the one hand, some previous studies on the link between rural out-migration and agricultural technology adoption found a positive and significant association (Mwungu et al., 2018; Maguza-Tembo et al., 2017; Tesfaye and Tirivayi, 2016). Added to these, a study conducted by (Tshikala, 2014) on the link between remittance from migration and agricultural technology adoption obtained a positive and significant association. Still, a study conducted by (Abebaw et al., 2019) on the effect of rural-urban migration on agricultural investment showed that participation in rural out-migration increases expenditure on livestock and pesticides. Moreover, a study conducted by Bhandari and Reddy, (2015) on the impact of migration on technology adoption in Kenya using data from the world bank and the two-stage least square estimation technique found that rural out-migration positively affects the use of improved seeds by farmers. In addition, a study conducted by Sun et al., (2021) on the impact of rural-urban migration on rice farmers' agricultural machinery expenditure indicated that rural-urban migration significantly increases households' expenditure on agricultural machinery.

On the other hand, Williams (2014) examined the impact of migration on technology adoption, natural resource conservation, and household welfare in Nepal using cross-sectional data and a three-stage least square technique of estimation, and the results indicated that migration and remittance decrease the number of natural resource conservation practices adopted by farmers. Similarly, Zegeye (2021) conducted a study on impact of remittance on technology adoption in Ethioppia using cross-sectional data and probit model, and the study found that remittance significantly reduces agricultural technology adoption in Ethiopia. Yet, Mesele et al. (2022) investigated the determinants of agricultural technology adoption using cross-sectional data and multinomial logit model, and found that households with lower remittance have a higher propensity to adopt agricultural technology. Though few studies have examined the impact of rural out-migration on technology adoption, they found mixed results, focused on the adoption of a single technology, and did not control the problem of self-selection bias. This study examined the impact of migration on the intensity of technology adoption by controlling self-selection biases.

Materials and methods

The study area

The Southern Nations, Nationalities, and People's (SNNP) regional state is one of the nine regional states in Ethiopia. The SNNP regional state accounts for 10 and 20 percent of the land area and the population of Ethiopia respectively. There are fifteen zones in SNNP regional state, and this study was conducted in the Hadiya and Kembata-Tembaro zones of the SNNP regional state. These two zones are the most densely populated and the primary sources of both internal and international migrants in Ethiopia (Degelo, 2015). Hosanna and Durame are the capital towns of the Hadiya and Kembata-Tembaro zones and are located 267km and 260km southwest of Addis Ababa respectively. The population of the Hadiya and Kembata-Tembaro zones was 1,747,356 and 996,969 people while the total land size was 3,593.31 and 1,355.90 square kilometers respectively (CSA, 2021). There are eleven and seven districts in Hadiya and Kembata-Tembaro zones respectively. While Soro and Lemo districts were selected from the Hadiya zone, the Angacha district was selected from the Kembata-Tembaro zone for this study purposively. These three districts are the leading sources of migrants (Kanko et al., 2013). The location of the sample districts is presented in Figure 1.



Source: Author compilation, 2021

Figure 1: Map of study area, and sample districts in Hadiya and Kembata Tembaro Zones.

Soro district is placed between 7°23' and 7°46' north latitudes and 37°18' and 37°23' east longitudes. The altitude of the district ranges from 840 to 2850 meters above sea level. The farming system of the district is a mixed system of crop production and livestock husbandry (SDARDO, 2021). Lemo district is located between 7°22' and 7°45' north latitudes, and 37°40' and 38°00' east longitudes. The altitude of the district ranges from 1900 to 2720 meters above sea level. Crop production and livestock husbandry are the chief livelihood source of the population (LDARDO, 2021). Anigacha district is found between 70°30' and 70°34' north latitudes and 370°83' and 370°88' east longitudes. The altitude of the district ranges from 1501 to 3000 meters above sea level. Crop and livestock productions and animal husbandry are the key sources of livelihood for the population in the district (ADRADO, 2021).

Data sources and collection tools

Cross-sectional data were collected from 415 sample rural households in three districts namely; Lemo, Soro, and Angacha in southern Ethiopia using structured questionnaires. Focus group discussions and interviews with key informants were also held to support the data collected using the questionnaire. Also, secondary data were gathered from the Central Statistical Authority of Ethiopia, the World Bank, the Food and Agriculture Organization, the United Nations Development Program, the Ethiopian Ministry of Labor and Social Affairs, the United Nations Department of Economic and Social Affairs, and other published and unpublished documents to get background information about the research area. The training was given to data collectors, and they gathered primary data using a survey questionnaire. A list of fourteen portfolios of agricultural technologies that include improved seed, chemical fertilizers, row planting, mulching, crop rotation, irrigation, compost, crop residuals, chemicals, terracing, animal fodder, inter-cropping, tree planting, and improved livestock were prepared, and each sample household was asked whether he/she adopted a particular technology or not. As a result, the outcome variable is a count variable with values between 0 and 14. Cross-sectional data on various socio-economic, demographic, and farm characteristics of rural households were also collected to quantify the impact of rural out-migration on the intensity of agricultural technology adoption in a migrant-sending rural area.

Sampling procedures and sample size

Sample zones and districts were selected purposively while sample Kebeles were selected using the proportionate random sampling technique. First, from the fifteen zones in the SNNP region, Hadiya and Kembata Tembaro zones were purposively selected for this study. This is because the two zones are the most densely populated, and the primary sources of both internal and international migrants in southern Ethiopia (Zewdu, 2015; Degelo, 2015). Second, from the 11 districts in the Hadiya zone, Soro and Lemo districts were selected while from the 7 districts in the Kembata-Tembaro zone, the Angacha district was selected for this study. Still, these districts are the main sources of international migrants in the Hadiya and Kembata-Tembaro zones (Kanko et al., 2013). There are 33, 33, and 17 rural Kebeles in Lemo, Soro, and Angacha districts, respectively. Third, 11 sample Kebeles were selected from the sample districts using proportionate random sampling, and accordingly, four Kebeles (Sundusa, Sonda, Shara, and Bona), three Kebeles (Kerekicho, Garba Fandide, and Bobicho), and four Kebeles (Haise, Shurmo, Jawe, and Sena) were selected from Soro, Angacha, and Lemo districts respectively. Fourth, sample *gots*[1] were randomly selected from each sample Kebele to prepare a sampling frame that contains the lists of households with no migrants, rural-urban migrants, and international migrants. Sample households were included in the study using a stratified random sampling technique from each sample got. As a result, 193, 85, and 137 sample households with no migrants, rural-urban migrants, and international migrants were used in this study respectively. This study employed the following Cochran (1963) formula to obtain an adequate sample size with 95, 50, and 5 percent confidence levels, degree of variability in the population, and the level of precision respectively.

$$n = \frac{Z^2 pqN}{e^2(N-1)+Z^2 pq}$$

where e, p, q, n, N, and Z are the measure of precision, the assumed level of variability in the population, one minus the level of variability in the population, the sample size of the study, the total population and the value of standard normal distribution respectively. The total households (N) in the three districts, degree of variability, and level

[1] Gots are the lowest level of administration in the study area which mostly contain more than 50 households. From a total of 147 gots in all sample Kebeles, 36 sample gots were included in the study.

of precision in this study were 69277, 0.5, and 0.005 respectively. Based on the above formula, a sample size of 383 was determined for the present study. But by adding ten percent of this figure to account for incomplete responses, a total of 421 questionnaires were distributed to enumerators and this study finally used data from 415 completed questionnaires.

Methods of data analysis

Both descriptive and econometric analyses were employed to analyze the data collected from sample households. To quantify the impact of rural-urban and international migration on the intensity of agricultural technology adoption, the value of the outcome variable which is the count of technologies adopted by each household lies between 0 and 14. The treatment variable is participation in rural out-migration which is a nominal variable with three categories[2]: households without migrants (j = 0), with rural-urban migrants (j = 1), and with international migrants (j = 2). Some control variables are also included while measuring the impact of rural out-migration on the outcome variable.

Specification of analytical model

The objective of this study is to quantify the impact of rural out-migration on the intensity of agricultural technology adoption by rural households. The new economics labor migration theory claims that households participate in rural out-migration by sending at least one family member to urban areas to reduce risks and overcome liquidity constraints. The implication of this theory is rural out-migration affects agricultural investment and the welfare of migrant-sending households in origin areas via remittance. In this study, to examine the impact of rural out-migration on the intensity of agricultural technology adoption, the number of technologies adopted by households is used as the outcome variable whereas the participation in rural out-migration is used as a treatment variable. The number of potential portfolios of agricultural technologies in this study is 14 and the value of the outcome variable lies between 0 and 14. As a result, the outcome variable is a count variable that follows a Poisson distribution.

In the empirical literature, though there are various competing models which are used to quantify the impact of an endogenous independent variable on a continuous outcome variable (Cameron and Trivedi 1998), there are very few extensions of such models which are used to examine the impact of an endogenous multinomial treatment on a non-negative count outcome variable. Recently, a multinomial treatment effects negative binomial model was developed by (Deb and Trivedi, 2006) to quantify the impact of endogenous variables on the count outcome variable. The multinomial treatment affects negative binomial regression controls for biases due to both observed and unobserved factors. That means if both the count outcome variable and the treatment variable are both endogenous variables, the use of multinomial endogenous Poisson regression produces unbiased and consistent estimates. On the one hand, participation in rural out-migration is not random and there is a problem of self-selection into migration. On the other hand, rural out-migration and the intensity of technology adoption may be affected by the same unobserved factors and this will lead to a biased and inconsistent estimate of the impact of rural out-migration on the intensity of technology adoption.

The estimation of the multinomial treatment effects negative binomial model involves two steps namely; the estimation of the participation equation and the estimation of the impact equation. First, the participation equation is estimated where rural out-migration is regressed on all covariates. Second, a negative binomial regression model is estimated to assess the impact of rural out-migration on the mean number of technologies adopted by a rural farmer. Assume that the i[th] household chooses one treatment from a set of choices that contains a control group, and EV_{ij}^* refers to the indirect utility of selecting the j[th] treatment, $j = 1,2,3 \ldots J$, and it is given by;

$$EV_{ij}^* = z_i' \alpha_j + \delta_j I_{ij} + \mu_{ij} \quad (1)$$

where Z_i' is a vector of covariates, α_j and δ_j are parameters to be estimated, μ_{ij} is the error term which is identically independently distributed, I_{ij} is a latent factor that includes the unobserved characteristics of the households which affect both the participation in rural out-migration and the intensity of technology adoption by households. These latent factors may include motivation, the propensity to work, and perception. It is assumed that the latent factors are independent of the error term, μ_{ij}. Suppose that d_j is a discrete variable that shows the observed treatment choices, and $d_i = (d_{i1}, d_{i2} \ldots d_{iJ})$. Assume further that

[2] Households with both rural-urban and international migrants are categorized under households with international migrants since their numbers are very few. Besides, rural-urban migrant is less likely to remit if his or her family has another international migrant.

$I_i = (I_{i1}, Ii2 \ldots I_{iJ})$, and the probability of treatment can be given by;

$$P_r(d_i|z_i, I_i) = g(z_i'\alpha_1 + \delta_1 I_{ij}, z_i'\alpha_2 + \delta_2 I_{ij}, \ldots . z_i'\alpha_J + \delta_J I_{iJ}) \quad (2)$$

where g is a multinomial probability distribution and is assumed to have a mixed multinomial logit model structure. In a mixed multinomial logit model where participation also depends on latent factors, the probability of choosing the j[th] an alternative is given by;

$$P_{ij} = \Pr(M_i = j/Z_{i,} I_i) = \frac{e^{(Z_i'\alpha_j + \delta_j I_{ij})}}{1 + \sum_{k=1}^{J} e^{(Z_i'\alpha_j + \delta_j I_{ij})}} \quad (3)$$

where P_{ij} is the probability of choosing a given status of rural out-migration, j is the number of categories for rural out-migration (j = 0,1,2), I_i is a latent factor and it is assumed that each choice is affected by a unique latent factor. The outcome variable in this multinomial treatment effects negative binomial regression is a count variable which is the number of technologies adopted by rural farmers (y_i = 0,1,2…14), and the expected outcome equation for the i[th] household is given by;

$$E(y_i|d_i, X_i, I_i) = X_i'\beta + \sum_{k=1}^{J} \gamma_{ij}\, d_{ij} + \sum_{k=1}^{J} \lambda_j\, I_{ij} \quad (4)$$

where X_i is a vector of exogenous covariates which affect the number of technologies adopted by the i^{th} farmer, β, γ_{ij} and λ_j are vectors of parameters to be estimated, and d_{ij} is the multinomial treatment variable with three categories. The coefficient of d_{ij} measures the impact of participation in rural out-migration on the mean number oftechnologies adopted by accounting for the problem of endogeneity. If the value of γ_{ij} is positive and significant, participation in rural out-migration increases the intensity of technology adoption by rural households. But if the value of γ_{ij} is negative and significant, participation in rural out-migration reduces the intensity of technology adoption by rural households. Hence, equation (4) simultaneously estimates the participation equation and the outcome equation by controlling for biases due to observed and unobserved factors.

Description of variables, and expected sign

The outcome variable is the count of technologies adopted by the i[th] household and it is a count variable with values between 0 and 14. The treatment variable is rural out-migration which is a nominal variable with three categories: households without migrants (j = 0), rural-urban migrants (j = 1), and international migrants (j = 2). Age, education, tropical livestock unit, saving, extension visit, non-farm participation, land renting out, soil fertility, cooperative membership, sales of livestock, age-square, and gender are used as control variables. Added to these, a dummy for return migrants and family size are used as exclusion restriction variables or instrumental variables. These instrumental variables are selected in such a way that they affect the participation equation or rural out-migration directly, but they do not directly impact the outcome equation which is the intensity of agricultural technology.

The age and education level of the household head are continuous variables and they are measured in years. Studies conducted by Massresha et al. (2021) and Fadeyi et al. (2022) on factors influencing technology adoption by small-holder farmers found that age and education are positively and significantly related to agricultural technology adoption. But a study conducted by (Dhraief et al., 2019) on factors affecting agricultural technology adoption found that the age of the household head and technology adoption are negatively and significantly associated. The same author found that non-farm participation and agricultural technology adoption are positively and significantly associated. This study also hypothesized a positive association between the non-farm participation of households with the intensity of agricultural technology adoption. A study conducted by (Ullah and Saqib, 2022) on determinants of technology adoption found extension visits and access to credit positively associated with agricultural technology adoption. Thus, the frequency of extension visits is expected to induce the technology adoption behavior of rural households. The same study found that the education level of the household head is negatively and significantly associated with agricultural technology adoption. Sales of livestock and land renting out provide rural households with income. They use farm income to acquire inputs, hire labor and acquire farmland. A study conducted by Fadeyi et al. (2022) on factors affecting technology adoption indicated that farm income positively and significantly impacts agricultural technology adoption by rural farmers. This study also hypothesized that participation in livestock and land markets is positively related to the intensity of agricultural technology adoption.

Besides, studies conducted by Feyisa (2020) and Massresha et al.(2021) on determinants of agricultural technology adoption by smallholder farmers indicated that the number of tropical livestock units and the frequency of extension visits are positively and significantly related to agricultural technology adoption. This study also hypothesized that tropical livestock units and the frequency of extension visits are positively related to the intensity of agricultural technology adoption. In this study, the gender of the household head is used as a dummy variable which assumes 1 for males and 0 for females. A study conducted by Massresha et al. (2021) on factors affecting technology adoption found that the likelihood of technology adoption in male-headed households is significantly higher compared to female-headed households. Besides, the saving of households is also expected to be positively associated with the intensity of agricultural technology adoption in rural households (Table 1).

Furthermore, a study conducted by Simtowe et al. (2011) on determinants of technology adoption found that cooperative membership is positively and significantly associated with agricultural technology adoption, and this study also hypothesizes that cooperative membership is positively related to technology adoption by small-holder farmers. A study conducted by Sun et al. (2021) on the effect of rural-urban migration on farmers' expenditure on agricultural machinery found positive and significant effects. Added to this, studies conducted by Mendola (2005 and Shi (2020) also indicated a positive and significant association between rural-urban migration and technology adoption. But a study conducted by Williams (2014) found a negative and significant association between technology adoption and remittance from migration.

Results and discussion

Descriptive and Mean Difference Test results

The mean age of rural to urban migrants, and international migrants are 23 and 26 respectively in the study areas while the mean years of schooling of rural to urban migrants and international migrants are 9.3 and 8.6 years respectively as presented in Table 2. This suggests that most of the rural out-migrants are young and better educated. The mean monthly income of rural-urban migrants and international migrants are Birr 892.5 and 12185.2 whereas the mean annual remittance from rural-urban migrants and international migrants to origin areas are Birr 862.9 and 22,527.2 Ethiopian birrs respectively.

Though the mean annual remittance from international migrants is higher, international migration is associated with a significant initial cost of migration. Further, the majority of the migrants in the study areas are male (75 percent) and unmarried (97 percent). Among all participants in rural out-migration, 94 percent of households

	Description	Measurement	Expected Relation
Outcome Variable	Count of technologies adopted	Scale	
Instrumental variables	Family Size	Scale	+
	Return Migrant (1 for presence, & 0 otherwise)	Nominal	+
Control Variables			
AGE	Age of household head in years	Scale	-
EDUC	Education level of household head in years	Scale	+
TLU	Tropical livestock units	Scale	∓
SAVING	Dummy for saving (1 for savers, 0 otherwise)	Nominal	+
NFP	1 for non-farm participation, & 0 otherwise	Nominal	∓
EXTN	Frequency of extension visits per year	Scale	+
LR	Land Renting Out (1 for rent, 0 otherwise)	Nominal	+
SL	Sales of livestock (1 for sales, & 0 otherwise	Nominal	+
SF	Soil fertility (1 for fertile land, & 0 otherwise)	Nominal	+
CM	1 for cooperative membership & 0 otherwise	Nominal	+
EDUCH	Highest education level in the family	Scale	+
AGE-SQ	Square of household age	Scale	+
GENDER	1 for male-headed, & 0 otherwise	Nominal	+
ANGACHA	1 for Angacha district, & 0 otherwise	Nominal	∓

Source: Author compilation, 2021)

Table 1: Variables description, measurement, and expected relationship.

	International		Rural-Urban		Total	
	Mean	Std. dev	Mean	Std. dev	Mean	Std. dev
Age of migrants	26.1	5.7	22.5	3.1	24.8	5.2
Education of migrants	8.6	2.2	9.3	1.8	8.8	2.1
Income at destination	12185.2	5566.4	2523.3	892.5	8676.1	6454.5
Annual remittance	22527.2	39979.5	1560.3	862.9	15203.8	33735.1
				Number		Percent
Marital status of migrants	Unmarried			215		97
	Married			7		3
Gender of migrants	Male			166		75
Remittance status	Recipient of remittance			209		94

Source: author computation, 2021

Table 2: Descriptive statistics of continuous and discrete attributes of migrants.

received remittance in the last year. While a study conducted by Abire and Sagar (2016) on determinants of international migration in southern Ethiopia indicated that male migrants constituted about 72.5 percent of international migrants in Hadiya and Kembata-Tembaro zones, a study conducted by Debnath (2022) on the benefit of remittance found that 92 percent of households with rural-urban migrants received remittance in rural India.

Also, South Africa is the primary destination for international migrants while Addis Ababa is the leading destination for domestic rural-urban migrants in the study area. Added to this, female migrants primarily travel to the Middle East whereas male migrants mainly move to South Africa due to the nature of job opportunities in destination areas. As indicated in Table 3, 33.8 percent of migrant-sending rural households have two or three migrant family members while 60 percent of migrant-sending rural households have one migrant family member in the study area. Moreover, 33 percent of rural households have at least one international migrant in the study areas. A study conducted by Tsedeke and Ayele (2017) on determinants of international migration in southern Ethiopia also found that 39 percent of households in the Hadiya and Kembata-Tembaro zones have at least one international migrant. As indicated in Table 3, the decision to out-migrate is made at the family level for the majority of migrants, and this supports the prediction of the new economics labor migration theory which claims that the decision to out-migrate is made at the household level. This theory also predicts that migrants send remittances to origin areas for four motives namely; altruism, insurance contract, loan contract, and investment (Lucas and Stark, 1985).

The use of remittances from rural-urban migrants and international migrants by migrant-sending rural areas is presented in Table 4. On one hand, remittances from rural-urban migrants are primarily used for household food consumption, clothing, and health expenditure by remittance-receiving rural households. For instance, more than two-thirds of remittances from rural-urban migrants are used for household food consumption. It seems that a higher proportion of remittances from domestic rural-urban migrants are used for consumption compared to agricultural investment. A study conducted by Debnath (2022) on the use of remittance in India also found that rural households spend remittance from rural-urban primarily on food, clothing, education, and health.

On other hand, rural households spend remittances from international migrants primarily on housing, food, livestock, and inputs. Therefore, international remittance-receiving rural households use remittance mainly for housing which includes the purchase of urban houses, construction of houses in rural areas, and purchase of urban land for house construction. For instance, more than half of remittances from international migrants are used for housing rural households. Besides, more than 15 percent of remittances from international migrants are also used for the purchase of livestock and agricultural inputs. The implication is international remittance-receiving households use remittance for asset augmenting, agricultural investment, and household consumption in the study area. This suggests that the uses of remittances by remittance-receiving rural households depend on the size of remittances or sources of remittances.

In this study, each sample household is presented with a list of fourteen portfolios of agricultural technologies that include improved seed, chemical

	Major destinations	Frequency	Percentage
Rural-Urban migrants (85)	Addis Ababa	47	55.29
	Hawassa	13	15.29
	Other cities	25	29.41
International Migrants (137)	Republic of South Africa	97	70.8
	Middle East	38	27.74
	Others countries	2	1.46
Migrants per household		Frequency	Percent
	1	133	59.9
	2	50	22.5
	3	25	11.3
	4	10	4.5
	5 and 6	4	1.8
	Total	222	100
Decision to migrate	Self	6	2.7
	Relatives	9	4.1
	Friends	11	5
	Family	196	88.3
	Total	222	100

Source: author computation, 2021

Table 3: destination of migrants, migrants per household, and decision to migrate

	Rural-Urban migration	International migration	
Use of remittance	Percent	Use of remittance	Percent
Food	69.87	Food	14.77
Clothing	19.21	Clothing	4.74
Education	3.02	Education	2.18
Health	4.27	Health	4.94
Inputs	1.76	Inputs	6.77
Housing	1.21	Housing	51.05
Livestock	0	Livestock	8.45
Labor	0	Labor	0.35
Mobile	0.66	Mobile	4.3
TV & Radio	0	TV& Radio	1.51
Solar	0	Solar	0.52
Other	0	Other	0.42

Source: author computation, 2021

Table 4: Percentage share of remittances used by migrant-sending households.

fertilizers, row planting, mulching, crop rotation, irrigation, compost, crop residuals, chemicals, terracing, animal fodder, inter-cropping, tree planting, and improved livestock, and was asked whether he/she adopted each technology or not. The descriptive result in Table 5 shows the count of various technologies adopted by rural households in the study area. While most of the households use fertilizers and chemicals, 45.06 percent of households use row planning in Hadiya and Kembata-Tembaro zones.

Similarly, 54.94 percent of households use improved seeds whereas 30.36 percent of households have improved livestock variety. Since Hadiya and Kembata-Tembaro zones are known for limited agricultural land, farm households grow oats, alfalfa, and desho grasses for their livestock. As indicated in Table 5, 58.07 percent of households use animal fodder in the study area. In addition,

Technologies	Count	Percentage	Technologies	Count	Percentage
Improved seeds	228	54.94	Crop residue	218	52.53
Fertilizers	411	99.04	Chemicals	386	93.01
Row planting	187	45.06	Soil terracing	285	68.67
Mulching	186	44.82	Fodder	241	58.07
Rotation	187	45.06	Inter-copping	262	63.13
Irrigation	28	6.75	Tree planting	270	65.06
Manure	249	60.00	Livestock	126	30.36

Source: author computation, 2021

Table 5: Distribution of the number of technologies adopted by rural households.

Technologies adopted	Migration status				Total	
	Without migrants		With migrants			
	Count	%	Count	%	Count	%
1-4	25	12.95	8	3.60	33	7.95
5-8	145	75.13	86	38.74	231	55.66
9-12	23	11.92	110	49.55	133	32.05
13-14	0	0.00	18	8.11	18	4.34
Total	193	100	222	100	415	100

Source: author computation, 2021

Table 6: Frequency distribution of agricultural technologies adopted by migration status.

households construct soil terracing (68.67percent) in Hadiya and Kembata-Tembaro zones primarily to grow desho, oats and alfalfa.

Moreover, the number of agricultural technologies used by rural households is compared by migration status, and the results are presented in Table 6. The result shows that the number of technologies used by about three-fourths of households without migrant family members lies between 5 and 8. However, the number of technologies used by about half of households with migrant family members lies between 9 and 12. This may suggest that migrant-sending rural households are more likely to adopt agricultural technologies compared to rural households without migrant family members.

The credit hypothesis predicts that participation in rural out-migration enhances technology adoption of migrant-sending households by lessening the liquidity constraints of households. Similarly, the risk hypothesis of the new economics labor migration theory predicts that participation in rural out-migration promotes technology adoption of migrant-sending households by reducing their risk aversion level. Though it seems from the descriptive result that the intensity of agricultural technology adoption is higher for households with rural out-migrants, the extent and the statistical significance of the impact of participation in rural out-migration on the intensity of agricultural technology adoption is quantified and presented in the next section under econometric results.

Multinomial treatment effects negative binomial regression model

This study also examined the determinants of the intensity of agricultural technology adoption and quantified the impact of rural labor out-migration on the intensity of agricultural technology adoption using the new economics labor migration theory as a theoretical framework, and the multinomial treatment effects negative binomial model as an analytical model. The multinomial treatment effects negative binomial regression was employed since it controls for biases due to both observed and unobserved factors (Deb and Trivedi, 2006). The outcome variable is the number of agricultural technologies adopted by households which is a count variable with values between 0 and 14. The key independent variable or the focal variable is participation in rural out-migration which is a nominal variable with three categories: households without migrants, with rural-urban migrants, and international migrants. Hence, the impact of participation in rural out-migration on the intensity of agricultural technology adoption is examined by including some control variables, and the result is presented in Table 7.

As presented in Table 7, the multinomial treatment effects negative binomial regression estimates the participation equation and the outcome equation simultaneously. First, it estimates the determinants of participation in rural out-migration, and the result is presented on the left-hand side in Table 7. Second, the outcome equation which is the determinant of the intensity of agricultural technology adoption by farmers is quantified by using the predicted value of rural-urban migration, and international migration from the first estimation as additional independent variables. The Wald test result showed that the chi-square value is statistically significant at 1 percent, and this suggests that the estimated model best fits the data at the hand.

The presence of return migrants and family sizes are used as instrumental variables in quantifying the impact of rural labor out-migration on the intensity of agricultural technology adoption by rural households. The instrumental variables are included in the participation equation but are excluded from the outcome equation. The coefficients of return migrants and family size are positive and statistically significant at 1 percent. That means the presence of return migrants in the village and family size increase the likelihood of participation in rural-urban and international migration by rural households. Besides, tropical livestock unit, saving of household, frequency of extension visits, land renting out, cooperative membership, and being female-headed household are directly and significantly associated with participation in international migration while the highest education level in the family and land fertility are indirectly and significantly related to international migration in Hadiya and Kembata-Tembaro zones. Likewise, the age of the household head, being from the Angacha district, age-square of household head, and land renting are significantly

Multinomial treatment effects NB regression			Number of observations = 415			
Log pseudolikelihood = -1054.7696			Wald chi^2(48) = 861.01 (0.000)			
	Rural-Urban migration		International migration (robust)		Technology adoption	
	Coeff.	Std. error	Coeff.	Std. error	Coeff.	Std. error
Rural-Urban					0.056	0.036
International					0.389	0.031***
Angacha District	-1.255	0.582**	-0.410	0.598	0.120	0.027***
Age of HH Head	0.501	0.260*	-0.046	0.260	-0.022	0.011**
Education of HH Head	0.087	0.069	0.037	0.078	0.001	0.003
Tropical Livestock Units	-0.007	0.172	0.481	0.159***	0.011	0.004**
Saving of HH Head	0.68	0.565	1.136	0.546**	0.049	0.025*
Non-Farm Participation	-0.216	0.489	-0.645	0.497	0.042	0.022*
Extension Visits	-0.054	0.123	0.494	0.126***	0.014	0.004**
Land Renting	1.119	0.558*	1.566	0.594***	0.044	0.028
Sales of Animals	-0.915	0.594	-0.617	0.604	0.048	0.025*
Land Fertility	-0.253	0.535	-1.169	0.542**	0.030	0.023
Cooperative Membership	0.281	0.644	1.479	0.619**	0.075	0.024***
Highest Education	-0.063	0.109	-0.229	0.102**	0.002	0.005
Age Square	-0.005	0.002*	0.001	0.002	0.0023	0.001**
Male_Headed	-1.261	0.916	-1.841	0.878**	-0.064	0.038*
Family Size	0.678	0.198***	0.690	0.198***		
Return Migrants	6.774	0.853***	6.276	0.938***		
Constant	-19.480	6.844	-8.047	6.422	2.176	0.283***
Lnalpha					-30.697	0.272***
Lambda_Outcome2					-0.019	0.003***
Lambda_Outcome3					-0.0003	0.0025
Alpha					4.660	1.270
Likelihood Ratio Test of Exogeneity						
Likelihood Ratio Value = 54.618			Probability of LR =0.000			

Note: ***, **, and * denote the statistical significance level at 1%, 5% and 10% respectively
Source: author computation, 2021

Table 7: Estimation results of multinomial treatment effects negative binomial model.

related to rural-urban migration in the study area.

The coefficient of participation in international migration is positive and significant at 1 percent and this suggests that the result supports the credit and risk hypotheses of rural out-migration. The risk and the credit hypotheses claim that participation in rural out-migration is caused by the lack of insurance and credit markets in rural areas. According to these two hypotheses, participation in rural out-migration induces a positive technology adoption behavior of households in migrant-sending rural areas by reducing the insurance and credit constraints of households. While the coefficients of intervention variables, rural-urban migration, and international migration, are interpreted as a percentage, the coefficients of other covariates in the outcome equation are interpreted like the coefficients of negative binomial regression (Deb and Trivedi, 2006). Hence, participation in international migration by households increases the likelihood of technology adoption by 38.9 percent and is statistically significant at a 1 percent level of significance.

However, participation in rural-urban migration increases the likelihood of technology adoption in rural households only by 5.6 percent and is statistically insignificant, and this may be due to the significant difference between the average remittance from international and rural-urban migrants in the study areas. This finding is consistent with the findings of some previous studies on the impact of participation in rural out-migration on the decision to adopt agricultural technology by migrant-sending rural households (Tesfaye and Tirivayi, 2016; Maguza-Tembo et al., 2017; Mwungu et al., 2018). But the finding of this study contradicts the findings of Williams (2014), Zegeye (2021), and Mesele et al. (2022) who found a negative and significant association between participation in migration and technology adoption by migrant-sending rural households. But the previous studies did not control for self-selection bias due to unobserved factors, and they focused on the adoption of a single technology.

Besides, the age of the household head, gender of the household head, frequency of extension visits, saving of households, non-farm participation, tropical livestock unit, and cooperative membership are significantly related to the intensity of agricultural technology adoption in Hadiya and Kembata-Tembaro zones. As observed in Table7, being from the Angacha district increases the log count of agricultural technology adoption of households by 0.120, and statistically significant at a 1 percent level. This suggests that the mean count of agricultural technology adoption by households is higher in the Angacha district compared to Lemo and Soro districts.

While the age of the household head is indirectly and significantly related, the age square of the household head is directly and significantly associated with the log count of agricultural technology adoption. By implication, the intensity of agricultural technology adoption is lesser at lower ages of household heads and more at higher ages of the household head. This shows the importance of experience to induce the technology adoption behavior of rural households. This finding is consistent with a study conducted by Masresha et al. (2021) while it contradicts the finding of a study conducted by Dhraief et al. (2019).

Further, non-farm participation has a direct and significant influence on the log count of agricultural technologies adopted by rural households, and this is consistent with the prior expectation. As presented in Table 7, participation in non-farm activities increases the log count of the agricultural technologies adopted by households, on average, by 0.042, and statistically significant. This suggests that participation in non-farm activities can promote agricultural technology adoption by lessening the liquidity constraints of rural households. Likewise, the coefficient of the dummy for household saving is positive and statistically significant. However, being male-headed households decreases the log count of agricultural technology adoption of households, on average, by 0.064, and statistically significant. The intensity of agricultural technology adoption is higher for female-headed households compared to male-headed households in the study area. This finding is consistent with Olawuyi and Mushunje (2019) who found a negative and significant association between being in a male-headed household and the intensity of agricultural technology adoption.

The coefficient of tropical livestock unit is positive and statistically significant at a 5 percent significance level, citrus paribus. If the tropical livestock unit increases by one unit, the log count of agricultural technologies adopted by households increases by 0.011, and this could be because livestock is the source of both food and income for agrarian rural households. Similarly, the frequency of extension visits is positively and significantly related to the log count of agricultural technology adoption by rural households. In other words, as the frequency of extension visits increases by one unit, the log count of agricultural technologies adopted by rural households increases, on average, by 0.0135, and statistically significant at a 1 percent significance level, citrus paribus. This implies that the frequency of extension visits can induce a positive technology adoption behavior in rural households by increasing access to information. This finding is consistent with Ullah and Saqib (2022), Feyisa (2020), and Massresha et al. (2021) who found a direct and significant effect of the frequency of extension visits on agricultural technology adoption of rural households.

Moreover, the coefficient of the dummy for cooperative membership is positive and statistically significant at a 1 percent significant level and it suggests that being cooperative membership increases the log count of agricultural technology adoption of rural households by 0.075. This could be because cooperative membership improves access to information which induces a positive technology adoption behavior in households. This finding is in agreement with a study conducted by Simtowe et al. (2011) who found a positive and significant association between cooperative membership and agricultural technology adoption. Still, the coefficient of participation in the livestock market is positive and significant, and this suggests that participation in the livestock market through sales of livestock increases the likelihood of agricultural technology adoption by households in the study area. In the same vein, a study conducted by Fadeyi et al. (2022) on factors affecting technology adoption indicated that participation in the livestock market via sales of livestock is positively and significantly associated with agricultural technology adoption by rural farmers.

Lastly, the alpha parameter is significantly different from zero, and this suggests that the specification and estimation of negative binomial regression for the outcome equation are more appropriate compared to Poisson regression for the count data under consideration. The likelihood ratio test result indicates that the null hypothesis of exogeneity is rejected at a 1 percent significance level, and the specification and the estimation of the multinomial treatment effects of negative binomial regression are appropriate.

Conclusion

There are few studies on the impact of rural out-migration on migrant-sending households' adoption of agricultural technology using the new economics labor migration theory (stark, 1985) as a theoretical framework, despite the abundance of studies on the impact of rural out-migration on migrants and migrant-receiving urban areas using the human capital theory of migration (Harris-Todaro, 1970) as a theoretical framework. Furthermore, despite the fact that there are few studies that have looked at the impact of rural out-migration on agricultural technology adoption in migrant-sending origin areas, the ones that have done so have tended to be narrow in scope, yield mixed results, and fail to account for self-selection bias resulting from unobserved factors. Therefore, using the new economics labor migration theory as a theoretical framework and the multinomial treatment effects negative binomial regression as an analytical model, this study investigated the impact of rural out-migration on the intensity of agricultural technology adoption of migrant-sending rural households in southern Ethiopia. Utilizing stratified random selection, data was gathered from 415 sample rural households in 2021.

Descriptive results showed that most of the rural out-migrants are better-educated, unmarried, male, and young. More than half of rural-urban migrants are directed to Addis Ababa whereas more than two-thirds of international migrants are directed to South Africa in the study area. Besides, one-third of rural households in the Hadiya and Kembata-Tembaro zones have at least one international migrant member while more than half of rural households have at least one migrant member. While remittance from rural-urban migrants is primarily used for consumption expenditure by rural households, remittance from international migrants is used for asset augmenting, and agricultural investment in addition to consumption expenditure.

According to descriptive findings, the majority of rural out-migrants are younger, male, unmarried, and better educated. In the research area, more than two-thirds of international migrants directed to South Africa whereas more than half of rural-urban migrants directed to Addis Abeba. Moreover, more than half of rural households have at least one migrant member, with one-third of rural households in the Hadiya and Kembata-Tembaro zones having at least one international migrant member. Remittances from overseas migrants are utilized for asset augmentation, agricultural investment, and consumption expenditure by rural households, but remittances from rural-urban migrants are predominantly used for consumer expenditure. Regression analysis showed that while the influence of migration from rural to urban areas is insignificant, participation in international migration significantly increases the likelihood of technology adoption in rural households by 38.9%. The intensity of agricultural technology adoption by rural households is negatively and significantly correlated with male-headed households and household age, while the frequency of extension visits, non-farm participation, saving, membership in cooperatives, sales of livestock, and tropical livestock unit are positively and significantly related to the intensity of agricultural technology adoption. The outcome is consistent with the labor migration theory's risk and credit hypotheses. To encourage the adoption of agricultural technology and stop the recent surge of rural out-migration in southern Ethiopia, policymakers should provide access to capital, public services, and viable off-farm employment in rural areas. Future research will look at how rural out-migration affects rural labor and land markets, as well as income inequality in migrant-sending rural areas.

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