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Migration and Farm Efficiency: Evidence from Northern Thailand

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Abstract

This paper investigates the relationship between labour migration and agricultural productivity in the Northern Province of Thailand. Drawing on maize production data from a household survey, we estimate a stochastic production function to evaluate the effects of migration, remittances and salient characteristics of migrants on the mean maize output and levels of technical efficiency. Evidence shows that remittances and number of migrant workers facilitate maize production. It was also found that remittances, duration of migration, gender and education of migrants enhance the productive capacity of maize farmers.

Keywords: Migration, stochastic frontier, technical efficiency, maize, Thailand

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1. Introduction

The role of migration and remittances is an important issue in agricultural development. Migration affects the agricultural activities and social life in the rural areas of developing countries. Stark (1991) and Rozelle and Taylor (1999) argued that migration can complement productivity growth in the farm sector by relaxing credit or risk constraints faced by agricultural households through remittances, and this could contribute to technological change and rural development. On the other hand, labour out-migration can also create labour shortages. A rapid development of the non-farm sector stimulates a rise in non-farm employment and the wage rate. A disparity of wage rate between farm and non-farm sectors creates farm labour out-migration from lower wage rate areas.

In Thailand, before the 1997 economic crisis, seasonal rural to urban migration was common during the dry season. Migrants of the northern provinces were the most mobile (20% of men and 13% of woman) (de Jong, Richter and Isarabhakdi 1996). After the crisis, many labourers from the urban areas returned to work back on the farms. The number of employed workers declined by one million persons between 1997 and 1998. Most of the low-skilled workers had to return to their home town and the agricultural sector absorbed the laid-off workers (Chalamwong and Amorntum 2002). As a result, the labour shortage has been partly resolved, but the reduction of remittances may also have a negative impact on farming households.

The unresolved question regarding labour migration and agricultural production is whether remittance incomes enhance production enough to compensate for the reduced availability of labour in any specific setting (Mochebelele, 2000). This has also been the focus of previous studies such as Rozelle, Taylor, and Debrauw (1999), Mochebelele (2000) and Taylor and Rozelle (2003).

In order to understand the complexity of the relationship between migration and agricultural productivity, this paper aims to examine the technical efficiency of maize farmers in the northern province of Thailand. We consider a stochastic frontier production function and examine the effects of migration and remittances on productivity and efficiency. While previous studies have considered factors such as human capital and household characteristics, we have extended the analysis by including various characteristics of migrants in the model.

The present paper is organised as follows. Section 2 provides a brief background of the study area and data used in the study. The method of analysis and empirical model is presented in Section 3. The empirical results are presented in Section 4, and conclusions are discussed in Section 5.

2. Study Area and Data

In Thailand, maize is an industrial crop, source of food, feed and export earning. The production of maize is insufficient for livestock production, as the statistics show that domestic demand is higher than the total production of maize (Office of Agricultural Economics 2006). The demand in the world market has also increased, with the value of export increased by 27% from 1996 to 2005.

The largest region for maize production is in Northern Thailand (53% of total area planted) because the geography of this area is appropriate for planting dry crops. Maize is one of the main cash crops and most people work in the agricultural sector. Thirty years ago, the major occupation in this area was farming and planting a poppy crop. The Thai government tried to encourage a change in the behaviour of the local people and montagnards[1], and they switched to planting industrial crops such as maize because it has a short production cycle and is less risky than other crops (Ekasingh 2004).

The data used in this paper were taken from the data set collected as part of the project, "Growth, crisis and resilience: household responses to economic change in rural Southeast Asia Evidence from Northern Thailand"[2]. This research project focused on the effects of economy-wide growth and shocks on agricultural land use, the labour market and educational decisions of rural households in poorly endowed rural areas. Aumpher[3]

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[1] Highland tribes in the north of Thailand.

[2] This project was funded by the Ford Foundation.

[3] An aumpher is a district.

Mae Chaem, in Chiang Mai province, was the sample area because it has experienced rapid agricultural development and has many migrants who had migrated to the urban areas in Chiang Mai and Bangkok. It is expected that there were significant influences of economic growth on resource allocation. Moreover, the economic crisis in 1997 led to the renewed pressures on land resources according to Coxhead and Plangpraphan (1999) who analysed these pressures using aggregate data from 324 households in two years (1998 and 1999).

From the survey data, there are 153 farmers were engaged in maize production. Detailed output and input variables, along with various household characteristics, were used in our analysis. Descriptive statistics are presented in Table 1. On average, maize production constituted about 75 per cent of the total household income. The average production of maize was approximately 4450 kg per household, which translates to a mean yield of 5827.61 kg per hectare. Maize production is highly variable, ranging from 100 kg to 20 tons per household. On average, about 15 kg per hectare of seed was used. About 83 kg per hectare of fertiliser was applied and 285 baht per hectare was spent on herbicides. The average pre-harvest and harvest labour use were about 29 person-days and 33 person-days, respectively.

The average age of household head varied from 29 to 80 years old and 68% of the household members were adults. The average age of migrants is 30 years old, with an average level educational attainment of 6 years. Most of them are seasonal migrants (77%) and they have migrated to other places between 1 and 5 years and the average of the duration of migration is of almost 3 years. There are about 87 households with migrants in the sampled data. The average remittance is 7777 baht per household per year.

Table 1: Descriptive statistics of output and input variables

Variable name	Mean	SD	Minimum	Maximum
Output/Input variables				
Maize harvested (kg/ha)	5827.61	3373.92	250	21750
Area (ha)	0.81	0.58	0.04	3.36
Seed (kg)	14.59	10.55	1	50
Fertiliser (kg)	82.82	69.87	0	460
Herbicide (baht)	285.39	198.82	0	1060
Pre-harvest labour (person-days)	29.39	36.81	3	284
Harvest labour (person-days)	33.49	42.05	0	420
Household characteristics and economic variables				
Age of the household head (years)	48.76	13.85	29	80
Education (years)	2.73	2.46	0	12
Adult ratio (%)	67.64	19.19	25	100
Proportion of maize income to total income	0.75	0.36	0.1	1
Remittances (baht per year)	7777	8383.91	0	36000
Age of migrant (years)	30	11.56	13	73
Years of schooling (years)	6	3.94	0	14
Duration of migration (years)	2.93	2.56	0.02	10

Some important characteristics of migrants are provided in Table 2. The majority of migrants were male (62.07%) because women have to look after children and disabled persons in the household. The migrants normally migrated within their province (77%) and only some of them got a job in a big city. There are many types of work that the migrants took, with a majority working in the service industry (70%). The main reason for migration was to increase family income, and about 63% sent remittances back to their family.

Table 2 Descriptive statistics of the migration variables

Variable name	Number	%
1. Sex		
Male	54	62
Female	33	38
2.Place of migration		
In province	67	77
Other provinces	19	22
Other countries	1	1
3. Nature of job as migrant		
Agricultural wage	4	5
Factory	7	8
Service	52	60
Construction	11	13
Salaried job	12	14
General wage	1	1
4. Reasons for migration		
Free from agricultural work	12	14
To increase income for family	48	55
To care for somebody	23	26
Gain experience	1	1
Went with spouse	1	1
Others	2	2
5. Sending remittances		
Yes	63	72
No	24	28

3. Method of Analysis and Empirical Model

We used a standard stochastic frontier production function, defined as:

$$Y_t = f(X_i, \alpha) \exp(\varepsilon_i), \qquad (1)$$

where Y_i is the output of farm i-th (i = 1, 2, ..., N); X_i is the corresponding matrix of inputs; α is a vector of parameters to be estimated; and ε_i is the error term that consists of two independent elements, V_i and U_i, such that $\varepsilon_i \equiv V_i - U_i$. The V_is are assumed to be symmetric identically and independently distributed errors that represent random variations in output as a result of factors outside the control of the farmers as well as the effects of measurement error in the output variable, variables excluded from the model and statistical noise. They are assumed to be normally distributed with mean zero and variance $\sigma^2_{v.}$ The U_is are non-negative random variables that represent the stochastic shortfall of outputs from the most efficient production. U_t is defined by truncation of the normal distribution with mean $U_i = \delta_0 + \sum^{J}_{j=1} \delta_j Z_{ji}$ and variance σ^2, where Z_j is value of the *j*-th explanatory variable associated with the technical inefficiency effect of farm *i*; and δ_0 and δ_j are unknown parameters to be estimated (Battese and Coelli 1995). The maximum likelihood method is used to estimate the parameters of both the stochastic frontier model and inefficiency effects model. The variance parameter of the likelihood function is estimated in terms of $\sigma^2_s \equiv \sigma^2_v + \sigma^2$ and $\gamma \equiv \sigma^2/\sigma^2_s$. The technical efficiency of production for the *i*-th farm is defined by

$$TE = exp\ (-U_i), \tag{2}$$

The technical efficiency index (TE_i) is equal to 1 if the farm is perfectly efficient and equal to zero if perfectly inefficient.

Stochastic frontier estimates of the frontier model defined by equation (1) were obtained by assuming first a Cobb-Douglas functional form and then a translog functional form. As a special case of the translog function, the Cobb-Douglas functional form imposes severe restrictions on the technology by restricting the production elasticities to be constant and the elasticities of input substitution to be unity. Using a likelihood-ratio test, we tested the Cobb-Douglas against the translog function to determine whether it is an adequate representation of the data, and found conclusive evidence that it was not[4]. Therefore, we have excluded this function from further consideration.

The specification of the translog functional form is given by

$$\ln Y_i = \beta_0 + \sum_{j=1}^{7} \beta_j \ln X_{ij} + \frac{1}{2}\sum_{j=1}^{7}\sum_{s=1}^{7} \beta_{js} \ln X_{ij} \ln X_{is} + \sum_{k=1}^{5} \phi_k D_k + V_i - U_i \tag{3}$$

where Y represents the quantity of animal feed corn (in kilograms); X_1 is the total seeds (in kilograms); X_2 is the total area planted to maize (in hectares); X_3 is the fertiliser (as nitrogen, phosphorus and potassium) (in kilograms); X_4 is the herbicide applied (as cost) (in baht); X_5 is the total labour before harvesting (person-days); X_6 is the total labour for

[4] To test H_0: $\beta_{js} = 0$, we use the LR statistic defined as $\lambda = -2\{\ln[L(H_0)]-\ln[L(H_1)]\}$ where $\ln[L(H_0)$ is the value of the log likelihood function under H_o. The value of λ is 134.242 and H_0 is rejected at the 5 per cent level of significance.

harvesting (person-days); X_7 is the migration remittances (baht-years); the input variable is zero- value. By using a dummy variable with the incidence of the zero observation, the appropriate parameters of Cobb-Douglas production functions can be estimated in an unbiased way (Battese 1997). D_1 is the dummy variable for fertiliser, with a value of 1 if $X_3 = 0$ and 0 if $X_3 > 0$; D_2 is the dummy variable for herbicide, with a value of 1 if $X_4 = 0$ and 0 if $X_4 > 0$; D_3 is the dummy variable for migration, with a value of 1 if the household does not experience migration and 0 if the household does experience migration; D_4 is the dummy variable for the receipt of remittances, with a value of 1 if $X_7 > 0$ and 0 if $X_4 = 0$, D_5 is the dummy variable for year, with a value of 0 if the year is 1998 and 1 if the year is 1999[5]; the subscripts, j, i and t refer to the j-th input ($j = 1,2,\ldots, 7$), i-th farmer ($i = 1,2,\ldots, 153$) and t-th year ($t = 1,2$), respectively; and the αs and βs are unknown parameters to be estimated.

Following Battese and Coelli (1995), we also consider a technical inefficiency model

$$u_{it} = \delta_0 + \sum_{j=1}^{12} \delta_j Z_{jit}, \tag{4}$$

where the δ_js ($j = 0,1,\ldots, 12$) are unknown parameters; Z_1 is age of the household head; Z_2 defines the years of education completed by the household head; Z_3 is credit received by the household for cropping; Z_4 is the amount of remittances; Z_5 represents the number of migrants in the household; Z_6 is the proportion of maize income to total income; Z_7 is the ratio of adults to total household size; Z_8 represents the period of migration; Z_9 defines the time of migration; Z_{10} is a dummy variable for the gender of the household head; Z_{11} denotes the age of migrant; and Z_{12} defines the education level of the migrant.

The age of household head could have negative or positive effects on efficiency. The coefficient would be positive if the older farmers are not willing to adopt better practices. On the other hand, older farmers may have more experience and knowledge of the production activities and be more reliable in performing production tasks, in which

[5] As mentioned earlier, data were collected for two years. The data set used here was a pooled data set for farmers engaged in maize production.

case the coefficient would be negative. Next, the coefficient of education is expected to have a negative sign because a higher level of education would help the farmers to increase the quality of maize production. The sign on the coefficient of the ratio of adult members of the household could be negative or positive. The coefficient would be negative if more adult members in the household mean more labour is available that is capable of performing farming tasks. The sign on the coefficient of the adult ratio could be positive if adult members have to work off-farm.

Among the economic factors, the credit variable could also have either a positive or negative effect on efficiency. The sign on the coefficient could be positive if the farmers get subsidised credit that distorts the efficiency of input usage. On the other hand, the sign on the coefficient could be negative if the access to credit allows farmers to exploit scale efficiency and release financial constraints on farm operators. The coefficient of the variable for the proportion of maize income to total income is expected to have a negative sign because maize is an important cash crop in this area and the farmers can get more income than from other crops. A high proportion of maize income to total income explains the significant effect on household income. It can be hypothesised that the households which have their main income from maize will pay greater attention to maize production, leading to increased efficiency. The sign on the coefficients of the remittances variable and the number of migrants in the family variable could be negative or positive. If there are many migrants and remittances, the farmers will get more money from the migrants to increase maize production, which would act in a manner similar to a release of the credit constraint. However, migration could affect social life and the morale of the farmers' families. In addition, labour supply may be insufficient for the crucial periods of planting and harvesting, causing bottlenecks, and then the coefficient of remittances and the number of migrants could be positive indicating greater technical inefficiency.

Of the non-economic factors, the sign on the coefficient of the period of time migrants have taken to work away from the farm is expected to be negative. The coefficient would be negative if the migrants have worked for many years because they would send more remittances to their families than the migrants who have worked for few years. If there are many migrants and remittances, the farmers will get more money from the migrants for improvement in agricultural production.

The coefficient of the gender of migrants could be positive. Male out-migration implies that there would be less workers in the farm. The sign on the coefficient of the age of migrants could be positive. The older the migrants, the less experienced they become in farming. The last variable, the education of migrant variable is expected to have a negative sign because a higher level of education can help the migrants to get more income, then the remittance that they send back to their families will increase.

We have estimated the empirical model using FRONTIER 6.1. We have conducted several tests to examine the validity of the model. The generalised-likelihood ratio test for the one-sided error was significant at 5% level (LR = 128.39).

4. Empirical Results

Production frontier estimates

The maximum likelihood estimates of the parameters of the translog stochastic frontier production function are presented in Table 3. Because the variables of the translog model were mean-corrected to zero, the first order coefficients are the estimates of elasticities at the mean input levels. Seed, farm area, fertiliser, herbicide, harvest labour and remittances are all significant at 1% level for the translog model, and pre-harvest labour is significant at 5%. The seed variable has a negative sign on its coefficient.

The coefficient of the dummy variable for migration has a negative sign, which implies that a higher number of migrants in the household reduce maize output because if the members of household migrate to get the jobs in the urban areas, the shortage of labour will affect the planting and harvesting activities of maize production. There is a negative association between the dummy variable for year and maize output, which indicates that the first year (1998) had more maize output than the second year (1999).

Table 3: Maximum likelihood estimates for parameters of the translog stochastic frontier production models for maize production in the north of Thailand

Variable	**Parameter**	**Coefficient**	**SE**
Constant	β_0	0.397^{***}	0.021
Seed	β_1	-0.153^{***}	0.023
Farm area	β_2	0.643^{***}	0.028
Fertiliser	β_3	0.236^{***}	0.036
Herbicide	β_4	0.253^{***}	0.017
Pre-harvest labour	β_5	0.050^{**}	0.027
Harvest labour	β_6	0.154^{***}	0.031
Remittance	β_7	0.227^{***}	0.288
Dummy variable for migration	ϕ_1	-0.073^{***}	0.020
Dummy variable for fertiliser	ϕ_2	-0.070^{***}	0.025
Dummy variable for herbicide	ϕ_3	-0.090^{***}	0.012
Dummy variable for remittance	ϕ_4	0.074^{***}	0.020
Dummy variable for year	ϕ_5	-0.120^{***}	0.010
Variance parameters	σ^2	0.179^{***}	0.021
Gamma	γ	1.000^{***}	0.000
Log-likelihood function		84.742	

Note: *, ** and *** denote significance at 10%, 5% and 1% respectively. This is an abridged form of the translog stochastic production function.

Technical inefficiency estimates

The maximum likelihood estimates of the parameters of the inefficiency model for the translog function are presented in Table 4. The coefficients of the variables of age, education, proportion of maize income to total income, period of migration and education of migrants in the inefficiency model are significant at 1% level. The coefficients of the variables of remittances, adult ratio and age of migrants are significant at 5%. The age variable has a negative association, indicating younger farmers tend to be more inefficient. It can be explained that the older farmers have more experience and knowledge of the production activities and are more reliable in performing production tasks. It is the same result as reported by Tauer (1995) whose research found that the productivity of farmers peaked between ages 35 and 45, where it was 30% greater than for farmers under age 25. Beyond 45 years of age, the productivity of farmers decreased with additional age. Lockheed, Jamison et al. (1980) and Phillips (1994) hypothesised that education has a positive effect on farmer efficiency. They found that on average 4 years of schooling can improve output by about 7.4%. In this study, education has a negative association, which indicates that a higher level of education can help the farmers to decrease inefficiency because they are better able to obtain new knowledge and skills to improve farm management.

The remittance variable has a negative association, indicating that higher remittances are associated with more efficient maize production. The proportion of maize income to total income also has a negative association with technical efficiency, which indicates that a greater proportion of maize income to total income is associated with greater efficiency. It is expected that maize is the important cash crop in this area because the farmers can get income faster than they can from other crops. Therefore, households that derive their main income from maize crop will pay attention to maize production and achieve increased efficiency in its production. The adult ratio variable has a positive association with technical inefficiency, which indicates that the higher the proportion of adult to total members of the household the more inefficient maize production is. It is possible that many adults are old members in the household who cannot work effectively if at all. The period of migration has a negative association with technical inefficiency. It can be said that if there are many of the members of household who migrate to work all year, the households will increase technical efficiency because they can invest more income from the remittances to improve production efficiency. The age of migrants has a positive association, explained by the fact that the migration of older migrants causes losing of farm experience. The final variable, the education of migrants, has a negative association with technical inefficiency which indicates a higher level of education can increase the income of migrants and they can send the remittance to help their families.

The generalised likelihood ratio test statistic was estimated to test the null hypothesis that the parameters are not significant for the following variables in the inefficiency model: credit, the number of migrants, time of migration and the gender of households. We found that we can not drop all of variables and therefore can not reject the null hypothesis. Therefore, the inefficiency model reported in Table 4 contains all variables.

Table 4: Maximum likelihood estimates for parameters of the inefficiency effects model of the translog functions for maize production in the north of Thailand

Variable	Parameter	Translog	
		Coefficient	SE
Constant	δ_0	1.073***	0.438
Age of household head	δ_1	-0.016***	0.005
Education of household head	δ_2	-0.086***	0.024
Credit	δ_3	-0.387	0.361
Remittances	δ_4	-0.00002**	0.000008
The number of migrants	δ_5	-0.132	0.230
Proportion of maize income to total income	δ_6	-0.243***	0.025
Adult ratio	δ_7	0.005**	0.003
Duration of migration	δ_8	-0.093***	0.038
Time of migration	δ_9	0.206	0.299
Gender of migrants	δ_{10}	-0.122	0.209
Age of migrants	δ_{11}	0.011**	0.005
Education of migrants	δ_{12}	-0.145***	0.031

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

Descriptive statistics for the time-invariant technical efficiency model are presented in Table 5. The overall mean for all the migrant farms in the two-year period is 0.86, implying that their production could be increased by 14% using the same amounts of inputs if they were able to reach maximum efficiency. On the other hand, the non-migrant farms have a mean technical efficiency of 10% less than the migration farms. It can be concluded that the migrant farms produce maize more efficiently than the non-migrants farms[6]. The maximum technical efficiency is 0.99, achieved by both a migrant farm and a non-migrant farm.

[6] We tested the sampling distribution of the difference between two means by using a *Z* test. The value of the test statistic is Z = -3.543 which falls in the rejection region. Thus, we reject H_0.

Table 5: Mean technical efficiency 1998-1999

	Migrant farms	Non-migrant farms
Mean	0.86	0.76
Standard deviation	0.16	0.18
Maximum	0.99	0.99
Minimum	0.34	0.30

The distribution of technical efficiency estimates is presented in Figure 1. A majority of migrant farms have technical efficiency estimates between 0.86 and 1.00, whereas non-migrant farms are distributed more widely. The efficiency indices for the non-migrant farms varied from 0.61 to 1.00, and 54% had technical efficiencies above the group's average whereas more than 60% of the migrant farms had efficiencies above the group's average. Only 9% of the migrant farms had efficiency indices less than 0.61 whereas more than 10% of the non-migrant farms had efficiencies in this range.

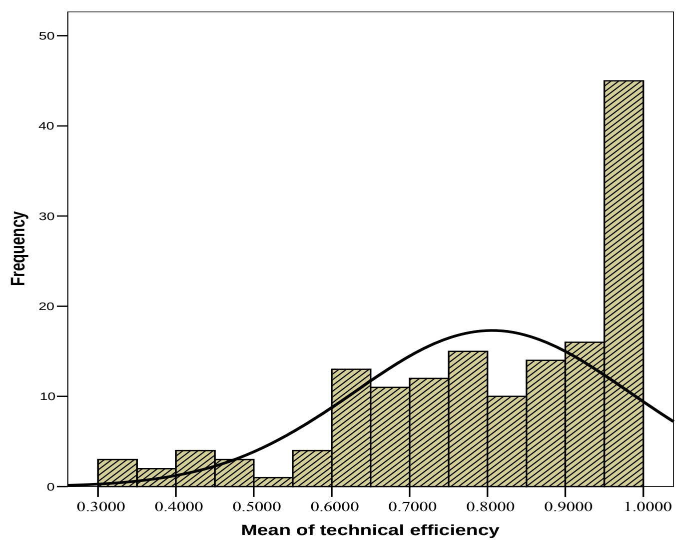

Figure 1: The distribution of technical efficiency

The comparison of technical efficiency in the non-migrant and migrant households implies that migrant farms have higher technical efficiency on average than the non-migrant farms. The migrant farms appear to have greater ability to allocate their inputs effectively. It can be said that the remittances from migrants can increase the efficiency of maize production because they can use remittances to buy fertiliser and hire pre- and post-harvest labour for their farming operations in a timely manner. The findings also suggest that the knowledge of farm management of the head of household can help increase efficiency in maize production. Scope exists for farmers in both categories to increase maize output. About 21% of the migrant farms and 46% of the non-migrant farms have technical efficiencies less than 0.76. Thus, migration and associated remittances combined with greater knowledge of farm management can help producers to increase technical efficiency.

Elasticities and return to scale

The parameters of the frontier model for the translog function indicate that the elasticity of output is highest with respect to the area planted to maize (0.643 at the mean input values). These elasticities are presented in Table 6. This elasticity is approximately triple the estimated fertiliser output elasticity (0.236) and herbicide output elasticity (0.253), which are in turn higher than the harvest labour output elasticity (0.154) and pre-harvest output elasticity (0.050).

The estimated returns-to-scale parameters, computed as the sum of estimated output elasticities of all input at their mean values, is 1.183 for the translog model. This estimate suggests increasing returns to scale on the frontier. The productivity of maize production in the north of Thailand could be increased by expanding the scale of maize farming on individual farms.

Table 6: Estimates of output elasticities for inputs in the stochastic frontier production function

Input	Translog
Seed	-0.153 (0.023)
Farm area	0.643 (0.028)
Fertiliser	0.236 (0.036)
Herbicide	0.253 (0.017)
Pre-harvest labour	0.050 (0.027)
Harvest labour	0.154 (0.031)
Returns to scale	1.183 (0.006)

Note: The figures in parentheses are standard errors.

5. Conclusions

In this paper, we use a stochastic frontier production model with inefficiency effects to the relationships between labour migration, remittances and maize productivity are analysed using a pooled-data set from the Northern Province of Thailand. Seasonal migration is common is the northern province, especially during dry season.

Our results indicate that remittances have positive and significant effect on maize production. Characteristics of migrants showed significant effect on the level of technical efficiencies of maize farmers. The average technical efficiency on migrant farms was 86 percent, which was more than 10% higher than on non-migrant farms. The age and educational attainment of the household head, remittances, proportion of maize income to total income, period of migration, and age and education of migrants in the household are found to have significant effects in decreasing technical inefficiency. The analysis of the relationship between migration and technical efficiency of farmers implies that excess labour from other sectors cannot change technical efficiency. The efficiency of allocation of inputs in maize production can be improved by using remittances to make more timely purchases of inputs and hired labour, and by improving the farm management knowledge of the household head.

Our findings about the effects of migration, remittances and migrant characteristics on maize production support those by Rozelle and Taylor (1999), who found that there are both positive and negative effects of labour migration on productivity. These findings suggest that increasing the quality and quantity of education in the rural area can help migrants get higher remittances. However, migration can also have a negative effect on maize production by causing shortages of labour in the agricultural sector. In order to solve this problem, an effective rural development program can reduce the number of people in farm households who migrate to get income in the other places. Finally, the duration of migration implies that permanent migrants have higher remittances than temporary migrants.

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