



**AgEcon** SEARCH  
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

*The World's Largest Open Access Agricultural & Applied Economics Digital Library*

**This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.**

**Help ensure our sustainability.**

Give to AgEcon Search

AgEcon Search

<http://ageconsearch.umn.edu>

[aesearch@umn.edu](mailto:aesearch@umn.edu)

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

# **Migration and Agricultural Efficiency**

Johannes Sauer  
Production and Resource Economics  
Technical University Munich, Germany  
jo.sauer@tum.de

Matthew Gorton  
Department for Agricultural Economics  
University of Newcastle, UK

Sophia Davidova  
Department for Economics  
University of Kent, Canterbury, UK

**Selected Paper prepared for presentation at the  
Agricultural & Applied Economics Association's 2014  
AAEA Annual Meeting, Minneapolis, MN, July 27-29, 2010**

Copyright 2014 by the authors. All rights reserved. Readers may make verbatim copies of this document for non-commercial purposes by any means, provided that this copyright notice appears on all such copies.

## **Migration and Agricultural Efficiency: evidence from Kosovo**

### **Abstract**

This paper investigates the effect of migration on farm technical efficiency drawing on a large and representative sample of agricultural households in Kosovo. A two-stage estimation procedure is applied: a frontier technique to estimate the effect of migration on farm efficiency, followed by a propensity score based matching approach to robustly estimate the sample average effect on efficiency for different levels of migration intensity. Migration is found to have an efficiency decreasing effect which is amplified for better educated workers. The observed negative effect of migration on efficiency is evident even at low levels of migration intensity.

**Key words:** migration, technical efficiency, agricultural households, Western Balkans, Kosovo

**JEL codes:** J43, J61, Q12

## **Migration and Farm Technical Efficiency: evidence from Kosovo**

### **Introduction**

Rural areas in many developing and transitional economies have witnessed significant outmigration in recent years. Outmigration has tended to be relatively greatest from the most impoverished regions, which also are typically those most reliant on agriculture as a source of income and employment (Bolganschi, 2011). The impact on rural areas can be considerable, for instance studies for Bulgaria (Dittrich and Jeleva, 2009), Romania (Surd, 2010) and Ukraine (Peacock, 2012) describe villages either almost entirely depopulated or consisting of elderly residents and their grandchildren after those of working age migrated in search of better paid employment. This leads to an important question: what has been the impact of migration on agricultural efficiency?

This paper analyses the impact of migration on farm technical efficiency in Kosovo, drawing on a large and representative survey of agricultural households. Technical efficiency of a given farm household refers to the “ratio of its mean production (conditional on its levels of factor inputs and farm effects) to the corresponding mean production if the farm utilized its levels of inputs most efficiently” (Battese and Coelli, 1992, p.191). Kosovo was selected as a typical case where outmigration has been particularly high (Gashi and Haxhikadrija, 2012) and the majority of rural households engage in farming (ASK, 2012a).

The paper focuses on the measurement of the effect of migration on technical efficiency as a primary objective for agriculture in Kosovo is to improve the

efficiency of production, in preparation for future desired accession to the EU. This is enshrined within Kosovo's Rural Development Plan, which states as an objective to improve 'competitiveness and efficiency of primary agricultural production' (ARCOTRASS, 2006). While measuring technical change as an essential component of growth in total factor productivity would yield insights into the sources and level of dynamism in the agricultural sector, this requires comprehensive panel data which are currently unavailable. Hence, we focus on the quantitative assessment of the impact of migration on technical efficiency. The relationship between migration and technical efficiency is investigated under the following propositions: (i) product and factor markets in Kosovo are imperfect and (b) a 'lost labor' effect is possible. The latter refers to the impact of migration on the production and income activities of those left behind (Pfeiffer and Taylor, 2007).

The impact of migration on farm efficiency is assessed using a two-stage estimation procedure: a frontier technique to estimate the effect of migration on farm technical efficiency, followed by a matching estimation approach to robustly estimate the sample average effect on efficiency for different levels of migration intensity. This two stage approach accounts for empirical identification problems and lagged decisions. The paper provides a more robust and nuanced analysis of the impact of migration on agricultural efficiency than present in some previous studies by considering the percentage of total available work time per household per year accounted for by migration (defined here as migration intensity).

The study contributes to the development literature, particularly the question of whether migration affects technical efficiency and if there is a relationship whether

it is positive or negative. As Taylor, et al. (2003, p.79) note, while there has been much research on the contribution of migrants to host economies, the literature, however, ‘has neglected other important aspects of migration, such as the effects of migration on source communities’. More recently, Taylor and Lopez-Feldman (2010, p.83) argue that the ‘analysis of migration impacts is complex and challenging’ and that ‘further econometric investigation is warranted’. While Kosovo can be considered an extreme case, most of rural Central and Eastern Europe has witnessed significant out-migration in recent years (OECD, 2012). Assessing the impact of migration on farm technical efficiency is thus of wider importance.

The next section presents the theoretical framework and previous empirical findings, followed by a discussion of the context of Kosovo. Subsequently, the data set and methodology are described. Particular attention is paid to the matching estimation approach. Results are then presented with relevant, wider conclusions drawn.

### **Theoretical considerations and previous empirical findings**

In recent decades various models of migration have been proposed and empirically tested (Massey, et al., 1993). In neo-classical theory, individuals decide to migrate based on a comparison of expected costs and benefits. More recently, the New Economics of Labor Migration (NELM) relates migration to production and incomes in the households (communities) from where migrants originate (Stark and Bloom, 1985). It challenges the neo-classical assumption of individual decision making, arguing instead for a household perspective on the spatial allocation of labor. The

NELM also acknowledges that migration typically occurs under conditions of market failure.

There are a number of potential reasons why migration may affect the technical efficiency of farms, bearing in mind that technical inefficiency is a measure of management error (Wouterse, 2010) and lower inefficiency does not correspond *per se* to higher yields or incomes. First, in the case of missing or imperfect credit and insurance markets, migrants can act as financial intermediaries who, through remittances, enable agricultural households, particularly those poor in liquid assets, to overcome credit and risk constraints (Taylor and Wyatt, 1996; Rozelle, et al., 1999). However, secondly, the impact of remittances on farm efficiency may be negative where they provide rural household members with an income that weakens the quality and intensity of their work. There is some evidence of this for Mali, where Azam and Gubert (2006) found that remittances provided incentives to shirk and reduce the intensity of work as households expect migrants to compensate any consumption shortfall. Gubert (2002) notes that migration creates a potential moral hazard – the effort of those who remain on the farm cannot be directly observed by migrants so that the latter cannot ascertain whether, for instance, low yields derive from shirking or non-controllable climatic factors. Thirdly, Michebelele and Winter-Nelson, (2000) argue that migrant households may find it more difficult to respond to intra-annual changes in farm conditions. This recognizes that farmers cannot perfectly forecast weather and thus also perfectly forecast how much and when labor input is required. Households with migrants may find it more difficult to mobilize labor rapidly and they employ it less effectively, so that they are less efficient than those who can employ the same input levels according to more flexible scheduling (Mochebelele and

Winter-Nelson, 2000). Finally, a detrimental effect may be observed in the absence of perfect substitutes for lost household labor (Arslan and Taylor, 2012; Atamanov and Van den Berg, 2012). For example, family members may be more committed than hired farm labor (Zaiceva and Zimmermann, 2008) since they are directly interested in the final results of the farming operation as they are residual claimants (Allen and Lueck, 1998). Thus, family labor is better incentivised (Wilson and Jadow, 1982), requires less monitoring of work effort and therefore is difficult to replace.

The theory relating to the relationship between migration and farm technical efficiency is, thus, ambivalent and empirical evidence is also conflicting (Table 1). For instance, Mochebelele and Winter-Nelson (2000) found that technical inefficiency was greater amongst non-migrant households in Lesotho, suggesting that migrant households benefited from cash resources that allowed them to buy inputs when required and improve overall farm management. Similarly, Nonthakot and Villano (2009) in their study of efficiency of maize farms in Northern Thailand estimated that the duration of migration positively impacted on technical efficiency. However, in their analysis the number of migrants had no significant impact on technical efficiency. Rozelle, et al. (1999), considering the impact of migration on maize yields and income, found that that the net impact of migration was negative although, in the case of income, remittances partially offset the loss. Jokisch (2002), while not formally testing the impact of migration on technical efficiency, argues that outmigration in Ecuador had little impact on farm production and land use.

Table 1 about here



One reason for the inconsistency in findings may stem from the treatment of migration. For example, as detailed in Table 1, much analysis has depended on a binary variable (non-migrant versus migrant households) that fails to capture what can be termed migration intensity: the percentage of household members absent and for how long. Nonthakot and Villano (2009) undertook a more sophisticated analysis considering also the duration and time of migration, as well as the gender, age and education of migrants. However, their analysis draws on a rather small dataset of 153 farmers.

Some previous work on farm efficiency in Central and Eastern Europe, based on input-oriented Data Envelopment Analysis (DEA), identifies surpluses (slacks) in input use, so that farms can non-proportionately reduce use of a particular input without harming output. For instance, Latruffe et al. (2005) found that Polish livestock farms in 1996 could have decreased their utilized land by 3.6% and labor input by 5.8% on average and still achieved the same level of output. However, by the year 2000 such slacks had diminished and Vasiliev et al. (2008) for Estonia also reports a decline in labor slacks for the period 2000-4. This trend may reflect a correction in labor input following the hoarding of workers by agricultural enterprises during the socialist era. Lissitsa and Odening (2005) report evidence of input slacks for agricultural enterprises in Ukraine but that an increase in workforce per hectare did not necessarily result in a reduction of technical efficiency. The analysis of slacks is complicated however where variations in input quality exist (Thiele and Brodersen, 1999) and cannot be estimated within approach taken in this paper.

## **Kosovo and Migration**

Kosovo is a small, Western Balkan economy, with an estimated population in 2011 of 1.7 million, of which 92.9% were ethnic Albanian (ASK, 2012b). In 2011, GDP per capita in Kosovo was €2745 (ASK, 2012a). The only European country with a lower level of GDP per capita in this year was Moldova (IMF, 2013).

Over several decades rural Kosovo has witnessed substantial outmigration. Not surprisingly, internal outmigration has been relatively greatest from the poorest regions, whilst there has been an inflow of migrants to more developed regions, particularly the capital city of Pristina (Vathi and Black, 2007). The main source of employment in Pristina is the public sector and related industries, specifically public administration, education and health (ASK, 2013). In general there is no agreement on whether migration has changed the educational composition of the labor force in Kosovo, since on average migrants have only completed secondary education (World Bank, 2011, Gashi and Haxhikadrija, 2012).

Estimates of international migration from Kosovo are unreliable. A country report prepared for the European Commission (Gashi and Haxhikadrija, 2012) quotes two estimates, varying from 415,000 to 800,000 migrants (ASK, 2012b). Although it is often claimed that migration from Kosovo was forced due to the military conflict in 1999, a UNDP (2010) survey of the reasons for migration identified that in only 18.2% of cases was the motive related to this, another 23.8% involved other political reasons, but the most important impetus was economic (42.9%). The latter is reflected in the pattern of emigration from Kosovo from the 1960s to 2011: the largest share of emigration (53.6%), took place post-conflict (UNDP, 2012).

Male international migrants work across the range of economic sectors including construction, services, tourism and hospitality, and manufacturing (Gashi and Haxhikadrija, 2012), with significant variations depending on the country of destination. Female migrants work mainly in the service sector (39%), manufacturing (26%) and domestic services (18%). Migration is thus not limited to a particular set of skills and few migrants work in agriculture. Permanent return migration has been low – around 3,000 persons in 2011 (Gashi and Haxhikadrija, 2012). The main motivations for return migration have been family reasons, deportation and homesickness (World Bank, 2011).

Due to its scale, migration (internal and international) has potentially significant ramifications for rural Kosovo, given that 62% of the resident population lives in rural areas and that the share of the labor force engaged in agriculture is 49% (ARCOTRASS, 2006). There is also little evidence that the flow of migration will subside in the near future: a recent UNDP (2012) survey reported that 15% of household heads intended to migrate and in 70% of these cases it was for economic reasons.

### **Data and Definition of Variables**

The data employed in the study were obtained from annual Agricultural Household Surveys (AHS) conducted by the Statistical Office of Kosovo (SOK) between 2005 and 2008. We constructed an unbalanced panel consisting of 2,217 observations spanning the years 2005 (555 observations), 2006 (495), 2007 (510), and 2008 (657). However, on average a farm is only in the sample for 1.1 years, so that the panel structure is rather weak. As an alternative we therefore estimated cross-sectional

specifications. The cross-sectional estimates confirmed the ones obtained by the panel specification, so we therefore concentrate on the latter.

To construct the samples, SOK (2010) applied a two-stage sampling process, first stratifying by region and then by farm size (cultivated area). Within each category, agricultural households were randomly selected for face to face interview. SOK (2010), for the purpose of the survey, defined a household 'as a union of persons that live together, and pool their income'. Agricultural households were delineated as those that cultivate more than 0.10 hectares (ha) of arable land or less than 0.10 ha of utilised arable land but had at least: 1 cow or 5 sheep/goats or 3 pigs or 50 poultry or 20 beehives.

The annual survey provides, for each household member, information on age, gender, educational attainment and the number of months, if at all, the family member lived away from the household in the previous 12 months. This was used to calculate migration intensity (the % of total available household work time accounted for by migration). Detailed information, on a plot by plot basis, relating to crops grown, yields, plot sizes and inputs used were collected.

Outputs included in the multi-output multi-input directional distance function for the estimation of technical efficiency were wheat, hay, potatoes, tomatoes, peppers and onions. These were chosen since they are the most common products in Kosovo for which a sufficiently large sample (2,217 households out of an initial sample of about 4,000 households) could be built, with all farm households producing some output. The survey collected data relating to the following inputs: land, labor, seeds, fertilizers, plant protection chemicals, fuel and machinery. Machinery value was estimated as the expected resale value expressed in Euros. All these inputs were

included in the distance function. Land was quantified in hectares. The remaining inputs were measured as expenditure in Euros. All input values were deflated.

Kosovo is divided into seven regions (*Ferizaj, Gjakove, Gjilan, Mitrovice, Peje, Prishtine* and *Prizren*). Regions were included as dummies to control for differences in agro-environmental conditions and infrastructure. To capture land fragmentation for each farm household, a Simpson Index (SI) was calculated (Blarel, et al., 1992). This can be expressed as:

$$1 - \sum_1^i A_i^2 / A^2 \quad (1)$$

where  $A_i$ , is the area of the  $i^{\text{th}}$  plot and  $A$  is the total farm area. The  $SI$  is defined between the values of 0 and 1, where a value of zero indicates no fragmentation of farm land into spatially separated plots. The larger the index score, the greater the level of land fragmentation. Table 2 presents key descriptive statistics for the sample.

Table 2 about here

The average sampled farm utilized 2.61 ha. Production is very fragmented even compared with neighboring Albania (Deininger, et al., 2012) with a mean of 8.38 plots per farm and a Simpson Index of 0.75. The majority of land is utilized for wheat and hay production. By Western European standards (European Commission, 2011), farms are poorly capitalized with the total (resale) value of machinery per agricultural household equating to €3,551 in 2005 values. Farming is labor intensive, drawing on input from household members. The use of hired (non-family) agricultural labor is minimal.

Part 2 of Table 2 distinguishes between migrant and non-migrant households. Households from which migration has occurred on average operated slightly larger farms: a mean of 2.86 ha compared to 2.39 ha for households which have not witnessed any migration. The average level of education amongst household members was very similar for both groups. There was also little difference between the two groups in terms of the degree of fragmentation of production. However, the use of tradable inputs (fertilizers, chemicals, seeds, fuel and machinery) was significantly higher for the migrant household group. Comparing average yields (dividing the land used by production amounts given in Table 2), reveals that they were similar for wheat, potatoes, onions and tomatoes. In the case of peppers, average yields were higher in the households from which no migration had occurred.

Table 3 details the scale of migration within the sample. Overall, migration is widespread: 45.8% of sampled households have witnessed some degree of migration with, therefore, 54.2% of households not experiencing any migration. Where migration has occurred it is most likely to be limited to one household member. Few households reported high levels of migration intensity, for example it is 50% or higher in only 3.8% of cases. The most common level of migration intensity is between 5 and 10% of total household work time available. Where migration has occurred, however, it tends to be long-term and permanent: the mean length of time that migrants were absent from the household in 2007 and 2008 was 11.2 and 11.1 months respectively.

Table 3 about here

## Empirical Modeling

a) *Directional distance function to evaluate the impact of migration on technical efficiency*

A directional output distance function (Färe and Primont, 1995, Chambers, et al., 1998) is employed to model technological processes and derive measures of technical (in)efficiency. To measure the efficiency of individual farms a parametric stochastic frontier approach is used. In this paper the Battese and Coelli (1995) estimator on the distance function is applied using an unbalanced panel data specification. The stochastic specification of the directional output distance frontier takes the form:

$$0 = \overrightarrow{D}_0(x, y + \mu g; g) + \varepsilon \quad (2)$$

where  $\varepsilon = v - u$ ;  $v \sim N(0, \sigma_v^2)$  and  $u \sim N^+(u, \sigma_u^2)$ . To estimate (2), the translation property of the directional output distance function is exploited. Following common practice (Färe, et al., 2005), we set  $g = 1$ , and by rearranging the following equation is obtained:

$$-\mu = \overrightarrow{D}_0(x, y + \mu; 1) + \varepsilon \quad (3)$$

Choosing  $\mu = y_1$ , which is farm household specific, sufficient variation on the left-hand side is obtained to estimate the specification given in (3). The output vector used is  $y = (\text{wheat, hay, pepper, tomatoes, onions, and potatoes})$  whereas the input vector is  $x = (\text{land, full-time labor, part-time labor, machinery, fuel, rented services, fertilizer, chemicals and seed})$ . Hence, the final specification estimated is:

$$\begin{aligned} -y_w = & \alpha_0 + \sum_{i=1}^M (\alpha_i y'_i) + \sum_{i=1}^M 0.5 \alpha_{ii} (y'_i)^2 + \sum_{i=1}^M \sum_{j=i+1}^M \alpha_{ij} (y'_i) (y'_j) + \\ & \sum_{i=1}^N (\beta_i x_i + 0.5 \beta_{ii} x_i^2) + 0.5 \sum_{i=1}^N \sum_{j=i+1}^N \beta_{ij} x_i x_j + \\ & \sum_{i=1}^M \sum_{j=1}^N \gamma_{ij} (y'_i) x_j + v - u \end{aligned} \quad (4)$$

where  $y'_i = y_i + y_w$  with  $y_w$  as the quantity of wheat produced and abstracting from farm household and time related variation.

The vector of technical inefficiency effects  $u$  in the stochastic frontier model outlined in (4) is specified as:

$$u = z\delta + w \quad (5)$$

with, according to the conceptual framework, the following components of the vector  $z$ : migration intensity, average education of household members, average age of household members, educational level of the head of the household, age of the head of the household, female to male ratio within the household, Simpson index (SI), total income, number of plots, region and year. The selection of these variables is in keeping with previous technical efficiency studies considering small-scale household farms (Hung, et al., 2007; Nonthakot and Villano, 2009; Rahman and Rahman, 2009; Latruffe and Piet, 2013). The random variable  $w$  is defined by the truncation of the normal distribution with mean of zero and variance,  $\sigma_w^2$ , such that the point of truncation is  $-z\delta$ , i.e.  $w \geq -z\delta$  (see Battese and Coelli, 1995). Abstracting from farm households and time related variations, technical efficiency is defined by:

$$TE = \exp(-u) = \exp(-z\delta - w) \quad (6)$$

The details of the corresponding likelihood function and its partial derivatives with respect to the individual parameters are presented in Battese and Coelli (1992; 1995).

The likelihood function is generally expressed in terms of the variance parameters with sigma  $\sigma^2 = \sigma_u^2 + \sigma_v^2$  and gamma  $\gamma = \sigma_u^2 / \sigma^2$  where  $0 < \gamma < 1$ .



*b) Matching estimation approach*

The second stage of the empirical analysis consisted of a matching approach to robustly estimate the sample average effect of migration on efficiency as well as the effect for different levels of migration intensity. As farm households are defined by a multitude of different characteristics over space and time, a sophisticated matching approach is required to accurately determine the effect of migration in a statistically robust way (Guo and Fraser, 2010). As we use survey based non-experimental data collected through the observation of agricultural household farming systems as they operate in practice (Rubin, 1997) this type of method allows for reducing multi-dimensional covariates to a one-dimensional score.

The underlying framework is Neyman-Rubin's model for causal inference using matching methods (Guo and Fraser, 2010). Farm households, selected into treatment (e.g. migration) and non-treatment groups, have potential outcomes ( $Y_0, Y_1$ ) in both states ( $W=0,1$ ): the one in which the outcomes are observed ( $E[Y_1|W=1]$ ,  $E[Y_0|W=0]$ ) and the one in which the outcomes are not observed ( $E[Y_1|W=0]$ ,  $E[Y_0|W=1]$ ). Unobserved potential outcomes that occur under either condition are missing data. A matching estimator directly imputes the missing data at the unit level by using a vector norm. Specifically, it estimates the values of  $Y_i(0)|W_i = 1$ , i.e. the potential outcome under the condition of control for the treatment participant, and  $Y_i(1)|W_i = 0$  as the potential outcome under the condition of treatment for the control participant. Hence, for each farm the estimator imputes the missing outcome by finding other farms in the sample whose covariates were similar but which were exposed to the other treatment (e.g. non-migration).

To ensure that the matching estimator identifies and consistently estimates the migration effect, two assumptions are critical (Abadie and Imbens 2002). Firstly, conditionally on the covariates, assignment to the migration group is independent of outcomes (“unconfoundedness assumption”). As migration is widespread in Kosovo and, as documented above, spread across economic sectors (e.g. public sector, construction, services, tourism and hospitality and manufacturing) and not biased to a particular skill set, the modelling assumption that assignment to a specific treatment group (migrate or not) is independent of outcomes (technical efficiency of the farm) appears reasonable. Secondly, we assume that the probability of assignment is bounded away from zero and one, i.e. there is sufficient overlap in the distribution of observed covariates (“identification assumption”) (Abadie and Imbens, 2011). The central challenge is the dimensionality of covariates or matching variables, because as their number increases, the difficulty of finding matches for treated farm households also rises. Matching estimators use the vector norm to calculate distances on observed covariates between a treated case and each of its potential control cases (i.e. counterfactuals).

Let us consider the set of observed covariates for farm  $i$ ,  $C_i$ , and the vector norm with positive definite matrix  $V$  defined as  $\|c\|_v = (c'Vc)^{1/2}$ . The distance between the vectors  $c$  and  $q$ , with the latter representing the covariate values for a potential match for farm  $i$ , can be defined as  $\|q - c\|_v$ .  $d_M(i)$  is the distance from the covariates for farm  $i$ ,  $C_i$ , to the  $M$ th nearest match with no migration satisfying:

$$\sum_{l:W_l=1-W_i} 1\{\|C_l - C_i\|_v < d_M(i)\} < M$$

and

$$\sum_{l:W_l=1-W_i} 1\{\|C_l - C_i\|_v \leq d_M(i)\} \geq M \tag{14}$$

and with  $1\{\cdot\}$  as the indicator function which is equal to one if the expression in brackets is true and zero otherwise (Abadie et al. 2004). Let then  $J_M(i)$  denote the set of indices for the matches for farm  $i$  that are at least as close as the  $M$ th match

$$J_M(i) = \{l = 1, \dots, N | W_l = 1 - W_i, \|C_l - C_i\|_v \leq d_M(i)\} \quad (15)$$

Finally, the number of elements of  $J_M(i)$  is  $\#J_M(i)$  and  $K_M(i)$  is the number of times farm  $i$  is used as a match for all observations  $l$  of the opposite treatment group weighted by the total number of matches for observation  $l$

$$K_M(i) = \sum_{l=1}^N 1\{i \in J_M(l)\} \frac{1}{\#J_M(l)} \quad (16)$$

The simple matching estimator estimates the pair of potential outcomes as:

$$\hat{Y}_i(0) = \begin{cases} Y_i & \text{if } W_i = 0 \\ \frac{1}{\#J_M(i)} \sum_{l \in J_M(i)} Y_l & \text{if } W_i = 1 \end{cases}$$

and

$$\hat{Y}_i(1) = \begin{cases} \frac{1}{\#J_M(i)} \sum_{l \in J_M(i)} Y_l & \text{if } W_i = 0 \\ Y_i & \text{if } W_i = 1 \end{cases} \quad (17)$$

where the unobserved outcome is estimated by averaging the observed outcomes for the observations  $l$  of the opposite treatment group that are chosen as matches for farm  $i$ . Based on these estimates the matching estimator for various treatment effects (i.e. migration levels) is:

$$\hat{t}_M^{me} = \frac{1}{N} \sum_{i=1}^N \{\hat{Y}_i(1) - \hat{Y}_i(0)\} = \frac{1}{N} \sum_{i=1}^N (2W_i - 1) \{1 + K_M(i)\} Y_i \quad (18)$$

and modified for the estimation of the average treatment effect for the treated farms

$$\hat{t}_M^{me,t} = \frac{1}{N_1} \sum_{i:W_i=1} \{Y_i - \hat{Y}_i(0)\} = \frac{1}{N_1} \sum_{i=1}^N \{W_i - (1 - W_i)K_M(i)\} Y_i \quad (19)$$

Abadie, et al. (2004) recommend using four matches for each unit since the drawback of using only one match is that the process uses too little information in matching. In finite samples the outlined matching estimator might be biased when matching is not exact. Following Abadie and Imbens (2002) we therefore adjust the difference within the matches for the differences in their covariate value whereby the adjustment is based on the estimates of the linear regression functions  $\mu_w(c) = E\{Y(w)|C = c\}$  for  $w=0$  or  $1$  using the matched observations. For the sample average treatment effect we estimate the regression:

$$\hat{\mu}_w(c) = \hat{\beta}_{w0} + \hat{\beta}'_{w1}c \quad (20)$$

for  $w=0,1$ , where

$$(\hat{\beta}_{w0}, \hat{\beta}_{w1}) = \operatorname{argmin}_{\{\beta_{w0}, \beta_{w1}\}} \sum_{i:W_i=w} K_M(i) (Y_i - \beta_{w0} - \beta'_{w1}C_i)^2 \quad (21)$$

where  $K_M(i)$  is used as a weight. The bias-corrected matching estimator for the average treatment effect is then:

$$\hat{\tau}_M^{bcm} = \frac{1}{N} \sum_{i=1}^N \{\hat{Y}_i(1) - \hat{Y}_i(0)\} \quad (22)$$

with the missing potential outcomes being:

$$\hat{Y}_i(0) = \begin{cases} Y_i & \text{if } W_i = 0 \\ \frac{1}{\#J_M(i)} \sum_{l \in J_M(i)} \{Y_l + \hat{\mu}_0(C_i) - \hat{\mu}_0(C_l)\} & \text{if } W_i = 1 \end{cases}$$

and

$$\hat{Y}_i(1) = \begin{cases} \frac{1}{\#J_M(i)} \sum_{l \in J_M(i)} \{Y_l + \hat{\mu}_1(C_i) - \hat{\mu}_1(C_l)\} & \text{if } W_i = 0 \\ Y_i & \text{if } W_i = 1 \end{cases} \quad (23)$$

Finally, the assumption of a constant treatment and homoscedasticity may not be valid for certain types of covariates. To account for such potential heteroscedasticity we use a second matching procedure, matching treated units to

treated units and control to control cases based on a variance estimation (Abadie, et al., 2004). The variance estimator for the sample average treatment effect is:

$$\hat{V}^{sample} = \frac{1}{N^2} \sum_{i=1}^N \{1 + K_M(i)\}^2 \hat{\sigma}_{W_i}^2(C_i) \quad (24)$$

Assuming that  $\sigma_w^2(c)$  varies by treatment  $w$  and covariate  $c$ , the conditional variance is estimated as the sample variance given in (24) augmented with the outcome for farm  $i$  itself,  $J'_M(i) \cup (i)$ :

$$\tilde{\sigma}_{W_i}^2(C_i) = \frac{1}{\#J'_M(i)} \sum_{j \in \{J'_M(i) \cup (i)\}} \{Y_i - \bar{Y}_{J'_M(i) \cup (i)}\}^2 \quad (25)$$

where  $\bar{Y}_{J'_M(i) \cup (i)}$  is the average outcome in this set (Abadie et al. 2004). Table 4 summarizes the two matching models estimated. The efficiency scores obtained from the frontier model are used as outcome variables whereas the different levels of migration intensities are used as indicator variables. As the estimation of the efficiency scores is based on input variables that are not used as matching controls but simultaneously are estimated also as a function of migration related variables, there is no inconsistency or bias related to this procedure.

Table 4 about here

The efficiency estimation is based on the assumption that the level of inefficiency is not independent of migration which is then the basic assumption for the matching estimations using the efficiency scores as outcome variables. We use the following variables as matching controls: the age of the head of the household, the educational level of the head of the household, the average age and educational level of household members, the female to male ratio per household, yearly and regional

dummies, the Simpson index to indicate the degree to which production is fragmented, measures to control for the degree of specialization and market integration of production, and finally a simple dummy to indicate whether the specific household owns a car. Specialization was measured in terms of the number of crops grown while market integration was measured as the percentage of crop output that was sold (i.e. not subsistence production). Collectively these variables serve the purpose of matching treated (i.e. migration affected) households as accurately as possible with non-treated households in the sample.

## **Results**

The overall model quality of the estimated distance frontier and the estimated matching models are largely satisfactory indicating the robustness of our empirical results. Table 5 reports the estimates for the directional output distance frontier function that gives the technical efficiency scores at household level. Figure 1 summarizes the distribution of technical efficiency scores. The mean efficiency for the whole sample has been estimated at 61.1% with a standard deviation of 24.3%, a minimum of 5.5% and maximum of 98.1%. The majority of farms in the sample show a technical efficiency level of more than 50%. The distribution of technical efficiency scores is similar to that reported for other emerging economies (Nonthakot and Villano, 2009). Distinguishing between those households with and without migration reveals a significant difference. The mean efficiency of households without any migration is 64.4%, while the comparable figure for households that have experienced migration is 57.1%.

Table 5 and Figure 1 about here

The overall model quality of the estimated distance frontier was evaluated using the value of the log-likelihood function and the estimated values for gamma and sigma. The highly significant estimate for gamma indicates that much of the variation in the composite error term is due to the inefficiency component. The highly significant estimate for sigma suggests that the consideration of production inefficiency plays a significant part in explaining households' production behavior. Different frontier specifications were estimated with the most appropriate selected based on various Lagrange Multiplier test statistics and the relative values for the Akaike Information Criterion.

Table 6 presents the estimations for the determinants of inefficiency. Migration intensity (based on % of total available work time per household per year) has an efficiency decreasing effect. This effect is highly significant even when region, year, socio-economic characteristics of the household (age, education, gender, income) and farm characteristics (number of plots, cattle etc.) are accounted for.

Table 6 about here

Regarding other additive terms, fragmentation of production, captured by both the Simpson Index and the number of plots, has a significant, negative effect on efficiency. This is consistent with recent findings on small-scale agriculture in Bangladesh (Rahman and Rahman, 2009), Bulgaria (Di Falco, et al., 2010) and Vietnam (Hung, et al., 2007). Moreover, both human capital (approximated by

education) and physical capital (farm equipment) decrease technical inefficiency. The finding for education is in keeping with the estimations of Nonthakot and Villano (2009). From this point of view it is disappointing that, according to UNDP (2012), only 4.6% of remittances are used for investment in education and 3.9% for business investment, including 0.8% for purchase of land. Total household income is not a significant determinant of technical efficiency.

The interaction effects indicate that the efficiency decreasing effect of migration is amplified in the case of better educated and older households (the latter measured by the average age of household members) and where the female to male ratio within the household is higher. This suggests that older, better educated and female farm workers who have migrated are more difficult to replace (absence of perfect substitutes) so that the impact of migration of such workers is relatively greater. The loss of better educated workers is aggravated by the reliance on family labor and lack of use of hired in labor. This implies that educated migrants are not effectively replaced on farm. However, the interaction effects for migration intensity\*female to male ratio and migration intensity\*average age of household members have signs that are unexpected, given the estimates of their respective additive terms, and the reasons for this are not readily apparent. The variable (migration intensity\*migration intensity) provides a check for the matching estimations discussed below and is consistent with these findings – there is significant and positive effect on technical inefficiency.

Table 7 reports the sample average treatment effects for changes in technical efficiency at the household level for different levels of migration intensity. The results



indicate that the impact of migration on technical efficiency is consistently negative across different levels of migration intensity, apart from between 50 and 60%. The negative impact on technical efficiency is greatest for those households with the highest level of migration intensity, namely migration accounts for between 60% and 90% of total available work time of the household in a particular year.

Table 7 about here

The results thus indicate that migration has a significant, efficiency lowering effect even at low levels of intensity. This includes where migration accounts for 5 or less per cent of total available work time per household in a particular year. Given the labor intensive nature of farming in Kosovo and the absence of perfect substitutes, with no hired in non-family workers, even relatively small levels of migration negatively affect technical efficiency.

The statistical quality of the estimated matching models is indicated by the significance of the treatment effects based on the Abadie-Imbens robust standard errors. This follows Abadie and Imbens (2008), who demonstrate that bootstrap based estimators do not provide reliable standard errors for the average nearest-neighbor matching case. To further check the reliability of the matching estimator chosen, the various treatment effects were estimated using alternative distance metrics. The estimated treatment effects vary only minimally in magnitude and statistical significance. To ensure that households that are too different are not matched, limits for the distance tolerances were imposed. Finally, the assumption of sufficient overlap in the distribution of observed covariates was tested for by determining the number of

observations that violate this assumption. Table 8 summarizes the results of the robustness checks with respect to the overall migration treatment (i.e. migration “yes” or “no”). Similar robustness tests have been conducted for all other matching models which largely confirmed the statistical quality of the applied matching procedure.

Table 8 about here

## **Conclusions**

Rural outmigration in Kosovo, as in many emerging and transitional economies, has been widespread and this paper tackles the important question of the impact of such migration on farm efficiency. The paper extends previous analysis by calculating migration intensity (rather than relying on crude, dichotomous measures of whether migration occurred or not) and applying a two-stage estimation procedure (frontier technique followed by a matching estimation approach).

The analysis identifies that there is a significant and negative ‘lost labor effect’ on farm efficiency. The negative effect of migration on technical efficiency is amplified for households with better educated family workers. This suggests the presence of labor market imperfections with farm households relying also exclusively on family labor. While remittances may partially compensate for the lost labor effect in some cases (Taylor, et al., 2003), for Kosovo total household income is not a significant determinant of technical efficiency and the proportion of remittances spent on upgrading human and physical capital appears small (UNDP, 2012). Migration has a significant negative effect on technical efficiency even at low levels of intensity but is greatest for the highest category of migration intensity (migration accounts for 60% to 90% of total available work time of the household in a particular year). Overall, the

findings for Kosovo indicate a significant, adverse effect of migration on farm technical efficiency.

## References

- Abadie, A., Drukker, D., Herr, J. L., Imbens, G. W., 2004. Implementing matching estimators for average treatment effects in Stata, *Stata Journal*. **4**, 290-311.
- Abadie, A., Imbens, G. W., 2008. On the failure of the bootstrap for matching estimators, *Econometrica*. **76**, 1537-1557.
- Abadie, A., Imbens, G. W., 2011. Bias-Corrected Matching Estimators for Average Treatment Effects, *Journal of Business & Economic Statistics*. **29**, 1-11.
- Allen, D and Lueck, D. (1998). The Nature of the Farm, *Journal of Law and Economics*, **41**, 343-386.
- ARCOTRASS, 2006. Study on the State of Agriculture in Five Applicant Countries, Kosovo Report.
- Arslan, A., Taylor, J. E., 2012. Transforming Rural Economies: Migration, Income Generation and Inequality in Rural Mexico, *J Dev Stud*. **48**, 1156-1176.
- ASK, 2012a. Gross Domestic Product Dataset, in Agjencia e Statistikave të Kosovës ed., Pristina.
- ASK, 2012b. Kosovo Population and Housing Census 2011, available at <http://esk.rks-gov.net/rekos2011/?cid=2,64>.
- ASK, 2013. Labour Force Survey Results 2012, available at <http://esk.rks-gov.net/ENG/labour-market/publications>.
- 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**, 620-630.
- Azam, J.-P., Gubert, F., 2006. Migrants' remittances and the household in Africa: a review of evidence, *J Afr Econ*. **15**, 426-462.

- Battese, G. E., Coelli, T. J., 1992. Frontier production functions, technical efficiency and panel data: With application to paddy farmers in India, *J Prod Anal.* **3**, 153-169.
- Battese, G. E., Coelli, T. J., 1995. A model for technical inefficiency effects in a stochastic frontier production function for panel data, *Empirical Economics.* **20**, 325-332.
- Blarel, B., Hazell, P., Place, F., Quiggin, J., 1992. The economics of farm fragmentation: Evidence from Ghana and Rwanda, *The World Bank Economic Review.* **6**, 233-254.
- Bolganschi, D., 2011. Rural Out Migration and Land Use in Moldova, available.
- Chambers, R. G., Chung, Y., Färe, R., 1996. Benefit and distance functions, *Journal of Economic Theory.* **70**, 407-419.
- Chambers, R. G., Chung, Y., Färe, R., 1998. Profit, directional distance functions, and Nerlovian efficiency, *Journal of Optimization Theory and Applications.* **98**, 351-364.
- Coelli, T. J., Rao, D. S. P., O'Donnell, C. J., Battese, G. E., 2005. *An Introduction to Efficiency and Productivity Analysis.* Springer, New York, NY.
- Deininger, K., Savastano, S., Carletto, C., 2012. Land Fragmentation, Cropland Abandonment, and Land Market Operation in Albania, *World Development.* **40**, 2108-2122.
- Di Falco, S., Penov, I., Aleksiev, A., van Rensburg, T. M., 2010. Agrobiodiversity, farm profits and land fragmentation: Evidence from Bulgaria, *Land Use Policy.* **27**, 763-771.
- Dittrich, E., Jeleva, R., 2009. The future of rural communities in Bulgaria, *Research in Rural Sociology and Development.* **14**, 107-126.

- European Commission, 2011. EU Farm Economics Overview, available at [http://ec.europa.eu/agriculture/rica/pdf/report\\_2008.pdf](http://ec.europa.eu/agriculture/rica/pdf/report_2008.pdf).
- Färe, R., Grosskopf, S., Noh, D. W., Weber, W., 2005. Characteristics of a polluting technology: theory and practice, *J Econometrics*. **126**, 469-492.
- Färe, R., Primont, D., 1995. *Multi-Output Production and Duality: theory and applications*. Kluwer, Norwell, MA.
- Gashi, A., Haxhikadrija, A., 2012. Social Impact of Emigration and Rural-Urban Migration in Central and Eastern Europe, Final Country Report: Kosovo, available at [ec.europa.eu/social/BlobServlet?docId=8859&langId=en](http://ec.europa.eu/social/BlobServlet?docId=8859&langId=en).
- Gubert, F., 2002. Do migrants insure those who stay behind? Evidence from the Kayes Area (Western Mali), *Oxford Development Studies*. **30**, 267-287.
- Guo, S., Fraser, M. W., 2010. *Propensity Score Analysis*. Sage, London.
- Hung, P. V., MacAulay, T. G., Marsh, S. P., 2007. The economics of land fragmentation in the north of Vietnam, *Aust J Agr Resour Ec*. **51**, 195-211.
- IMF, 2013. World Economic Outlook Database, in I. M. Fund ed., Washington, D.C.
- Jokisch, B. D., 2002. Migration and agricultural change: The case of smallholder agriculture in highland Ecuador, *Hum Ecol*. **30**, 523-550.
- Kumbhakar, S. C., Lovell, C. A. K., 2000. *Stochastic frontier analysis*. Cambridge University Press, Cambridge, UK.
- Latruffe, L., Piet, L., 2013. Does land fragmentation affect farm performance? A case study from Brittany, France, available.
- Lissitsa, A., Odening, M., 2005. Efficiency and total factor productivity in Ukrainian agriculture in transition, *Agricultural Economics*. **32**, 311-325.

- Massey, D. S., Arango, J., Hugo, G., Kouaouci, A., Pellegrino, A., Taylor, J. E., 1993. Theories of international migration: a review and appraisal, *Population and Development Review*. **19**, 431-466.
- Mochebelele, M. T., Winter-Nelson, A., 2000. Migrant labor and farm technical efficiency in Lesotho, *World Development*. **28**, 143-153.
- Nonthakot, P., Villano, R. A., 2009. Impact of labour migration on farm efficiency: a study of maize farming in Northern Thailand, *Asia-Pacific Journal of Rural Development*. **19**, 1-16.
- OECD, 2012. International Migration Outlook, available at <http://www.oecdbookshop.org/oecd/display.asp?K=5K9CSF15F9XW&CID=&LANG=EN>.
- Peacock, E. A., 2012. The Authentic Village and the Modern City: The Space-Time of Class Identities in Urban Western Ukraine, *Anthropology of East Europe Review*. **30**, 213-236.
- Pfeiffer, L., Taylor, J. E., 2007. Gender and the impacts of international migration: Evidence from rural Mexico, in A. R. Morrison, M. Schiff and M. Sjöblom eds., *The International Migration of Women*. World Bank, Washington D.C.
- Rahman, S., Rahman, M., 2009. Impact of land fragmentation and resource ownership on productivity and efficiency: The case of rice producers in Bangladesh, *Land Use Policy*. **26**, 95-103.
- Rozelle, S., Taylor, J. E., deBrauw, A., 1999. Migration, remittances, and agricultural productivity in China, *Am Econ Rev*. **89**, 287-291.
- Rubin, D. B., 1997. Estimating causal effects from large data sets using propensity scores, *Annals of Internal Medicine*. **127**, 757-763.

- SOK, 2010. Agricultural Household Survey 2008, available at <http://esk.rks.gov.net/ENG/agriculture/publications>.
- Stark, O., Bloom, D. E., 1985. The New Economics of Labor Migration, *Am Econ Rev.* **75**, 173-178.
- Surd, V., 2010. Restraints and opportunities of the Romanian rural areas, *Revija za geografijo-Journal for Geography.* **5**, 55-66.
- Taylor, J. E., Lopez-Feldman, A., 2010. Does Migration Make Rural Households More Productive? Evidence from Mexico, *J Dev Stud.* **46**, 68-90.
- Taylor, J. E., Rozelle, S., de Brauw, A., 2003. Migration and incomes in source communities: A new economics of migration perspective from China, *Econ Dev Cult Change.* **52**, 75-101.
- Taylor, J. E., Wyatt, T. J., 1996. The shadow value of migrant remittances, income and inequality in a household-farm economy, *The Journal of Development Studies.* **32**, 899-912.
- Thiele, H., Brodersen, C. M., 1999. Differences in farm efficiency in market and transition economies: empirical evidence from West and East Germany, *European Review of Agricultural Economics.* **26**, 331-347.
- UNDP, 2010. Kosovo Remittance Study 2010, available at [www.kosovo.undp.org/repository/docs/Final-english.pdf](http://www.kosovo.undp.org/repository/docs/Final-english.pdf).
- UNDP, 2012. Kosovo Remittance Study. UNDP, Pristina.
- Vasiliev, N., Astover, A., Mötte, M., 2008. Efficiency of Estonian grain farms in 2000-2004, *Agricultural and Food Science.* **17**, 31-40.
- Vathi, Z., Black, R., 2007. Migration and poverty reduction in Kosovo, available at <http://94.126.106.9/R4D/PDF/Outputs/MigrationGlobPov/WP-C12.pdf>.



- Wilson, G. W., Jadow, J. M., 1982. Competition, profit incentives, and technical efficiency in the provision of medicine eervices, *Bell Journal of Economics*. **13**, 472-482.
- World Bank, 2011. Migration and Economic Development in Kosovo, available at [http://siteresources.worldbank.org/INTKOSOVO/Resources/Migration\\_and\\_Economic\\_Development\\_in\\_Kosovo\\_WB\\_report.pdf](http://siteresources.worldbank.org/INTKOSOVO/Resources/Migration_and_Economic_Development_in_Kosovo_WB_report.pdf).
- Wouterse, F., 2010. Migration and technical efficiency in cereal production: evidence from Burkina Faso, *Agricultural Economics*. **41**, 385-395.
- Zaiceva, A., Zimmermann, K. F., 2008. Scale, diversity, and determinants of labour migration in Europe, *Oxford Rev Econ Pol*. **24**, 427-451.

**Table 1: Summary of previous research on migration and farm technical efficiency / productivity**

Author	Data	Method	Measure(s) of migration	Findings
Jokisch (2002)	Ecuador	Farm survey, Chi square comparison of migrant and non-migrant households	Dummy variable: household had a member in US or not	No significant relationship between migrant status and agricultural productivity
Mochebelele and Winter-Nelson (2000)	Lesotho	Stochastic frontier model	Dummy variable: farms sending migrant to South Africa versus those who did not	Greater technical inefficiency among non-migrant households
Nonthakot and Villano (2009)	Northern Thailand	Stochastic frontier production function	Number of migrants, gender, education and age migrants, duration and time of migration	Duration of migration positively impacts on technical efficiency. Number of migrants, time and gender not significant. Education and age of migrants have positive and negative impact on technical efficiency respectively
Rozelle, et al. (1999)	Northeast China	Regression with dependent variable maize yields	Number of migrants	Migration has significant and negative effect on yields
Taylor and Lopez-Feldman (2010)	Mexico, rural household survey	Migration probit, endogenous switching regression strategy	Dummy variable: household had a member in US or not	Higher productivity of land in migrant-household group

**Table 2: Descriptive Statistics for the Sample (Part 1)**

<b>Variable</b>	<b>Mean</b>	<b>Minimum</b>	<b>Maximum</b>	<b>Std. Dev.</b>
All households (n=2,217)				
Land area used for wheat production (ha)	1.25	0.0300	150.0	4.007
Land area used for hay production (ha)	1.24	0.0050	30.7	1.729
Land area used for pepper production (ha)	0.03	0.0003	3.0	0.1614
Land area used for tomato production (ha)	0.01	0.0003	0.9	0.0287
Land area used for onion production (ha)	0.02	0.0004	5.2	0.1597
Land area used for potato production (ha)	0.05	0.0004	10.2	0.3087
Share of Male Headed Households (%)	97.56			
Education of household head (level)	3.98	1	9	2.0094
Average age of household members (years)	29.41	13	76.5	7.7184
Average education of household members (category 1-9)	3.36	1.5	7.4	0.8763
Full-time labor per year (no of household members)	1.13	0	21	1.6109
Part-time labor per year (no of household members )	1.50	0	14	1.6646
Utilized land area (ha)	2.61	0.20	151.66	4.6631
Machinery value (in 2005 values in Euro)	3550.64	0	101826.5	5759.221
Simpson Index	0.75	0.020	0.941	.1148
Number of plots	8.38	2	28	3.0827
Wheat production (in kg)	4562.16	1.25	525000	13919.24
Hay production (in kg)	3561.15	1.15	65000	5458.271
Pepper production (in kg)	623.78	3	90000	3880.13
Tomato production (in kg)	226.25	4	24000	937.5705
Onion production (in kg)	226.71	2	97000	2244.39
Potato production (in kg)	1247.03	10	450000	11336.87
Fertilizer (in 2005 values in Euro)	352.70	0	16632	691.8499
Chemicals (in 2005 values in Euro)	47.76	0	3740	168.3445
Seed (in 2005 values in Euro)	177.09	0	10000	475.8605
Fuel (in 2005 values in Euro)	265.48	0	15000	595.2668

**Table 2: Descriptive Statistics for the Sample (Part 2)**

Variable	Households with migrant members (n=1,016)				Households without migrant members (n=1,201)			
	Mean	Minimum	Maximum	Std. Dev.	Mean	Minimum	Maximum	Std. Dev.
Land area used for wheat production (ha)	1.48	.0700	150.0	5.3078	1.06	.0300	50	2.3984
Land area used for hay production (ha)	1.25	.0200	30.7	1.7001	1.24	.0050	21.5	1.7548
Land area used for pepper production (ha)	0.03	.0003	1.95	.1401	0.03	.0005	3	0.1774
Land area used for tomato production (ha)	0.01	.0003	0.9	.0365	0.009	.0004	0.4	0.0197
Land area used for onion production (ha)	0.02	.0004	5.15	.2279	0.013	.0004	1.3	0.0554
Land area used for potato production (ha)	0.05	.0004	10.2	.3629	0.05	.0010	5.1	0.2541
Share of Male Headed Households (%)	97.05				98.01			
Education of household head (level)	3.82	1	11	2.0168	4.12	1	11	1.9942
Average age of household members (years)	28.67	13	76.5	6.7578	30.05	13	76	8.3981
Average education of household members	3.35	1.7	7	.8381	3.37	1.5	7.375	.9074
Full-time labor per year (no of household members)	1.29	0	21	1.7657	0.99	0	10	1.4527
Part-time labor per year (no of household members )	1.74	0	14	1.8650	1.29	0	11	1.4432
Utilized land area (ha)	2.86	0.19	151.65	5.8432	2.39	0.23	56.11	3.3431
Machinery value (in 2005 values in Euro)	4473.76	0	78104.7	6399.987	2769.72	0	101826.5	5027.362
Simpson Index	0.76	0.093	.9413	.1098	0.74	0.019	.9317	.1178
Number of plots	8.87	4	28	3.3018	7.96	2	23	2.8198
Wheat production (in kg)	5506.58	4.5	525000	18944.32	3763.21	1.25	195000	7268.43
Hay production (in kg)	3803.22	1.15	65000	5811.92	3356.37	1.25	65000	5133.687
Pepper production (in kg)	610.98	5	60000	3252.61	634.61	3	90000	4342.073
Tomato production (in kg)	255.89	4	23500	1038.39	201.18	10	24000	842.5449
Onion production (in kg)	315.41	5	97000	3258.78	151.67	2	10000	554.4719
Potato production (in kg)	1381.82	10	450000	15024.93	1132.99	10	120000	6809.427
Fertilizer (in 2005 values in Euro)	391.63	0	16632	883.3212	319.78	0	7176	470.7272
Chemicals (in 2005 values in Euro)	56.36	0	3740	197.0513	40.48	0	3500	139.1964
Seed (in 2005 values in Euro)	214.47	0	10000	650.5898	145.47	0	3100	240.7654
Fuel (in 2005 values in Euro)	293.57	0	15000	698.8437	241.72	0	5000	489.9277

**Table 3: Extent of Migration from Farm Households**

	Number	% of sample
Households from which migration occurred	1016	45.8
Households without migration	1201	54.2
Households with one migrant	663	29.9
Households with more than one migrant	353	15.9
Households with up to 5% migration intensity <sup>a</sup>	31	1.4
Households with $\geq 5 < 10\%$ migration intensity <sup>a</sup>	401	18.1
Households with $\geq 10 < 15\%$ migration intensity <sup>a</sup>	84	3.8
Households with $\geq 15 < 20\%$ migration intensity <sup>a</sup>	86	3.9
Households with $\geq 20 < 30\%$ migration intensity <sup>a</sup>	160	7.2
Households with $\geq 30 < 40\%$ migration intensity <sup>a</sup>	112	5.1
Households with $\geq 40 < 50\%$ migration intensity <sup>a</sup>	56	2.5
Households with $\geq 50 < 60\%$ migration intensity <sup>a</sup>	58	2.6
Households with $\geq 60 < 90\%$ migration intensity <sup>a, b</sup>	28	1.2

<sup>a</sup> migration intensity expressed as % of total available work time per household per year

<sup>b</sup> due to small numbers of observations we have aggregated households showing a migration intensity of more than 60% and less than 90% into one category

**Table 4: Overview of Matching Models**

$W_i$	$Y_i$	$C_i$	$N$	$M$	$wm$	$bc$	$rm$
<p><i>Model 1 'migration intensity'</i></p> <p><math>W_{MIG}</math> - level of migration intensity</p> <p>(0 - falls not in specific migration category, 1 - falls in specific migration category, migration categories: &gt;0%&lt;=5% of total work time per household (hh) and year used by migrants &gt;5%&lt;=10% &gt;10%&lt;=15% &gt;15%&lt;=20% &gt;20%&lt;=30% &gt;30%&lt;=40% &gt;40%&lt;=50% &gt;50%&lt;=60% &gt;60%&lt;=90%)</p>	<p>Technical efficiency per farm household and year</p>	<p>age of household head, educational level of household head, average age of household members, average educational level of household members, female to male ratio, year dummies for 2006, 2007 and 2008 (year 2005 as reference), regional dummies for Gjakove, Gjilan, Mitrovice, Peje, Prishtine, Prizren (region Ferizaj as reference), number of crops grown, % of crop output marketed, Simpson index, car ownership</p>	2152	4	Inverse variance	4	10
<p><i>Model 2 'migration'</i></p> <p><math>W_{MIG}</math> – indicator for migration</p> <p>(categories: 0 – no migration for hh and year 1 – migration for hh and year)</p>	<p>Technical efficiency per farm household and year</p>	<p>age of household head, educational level of household head, average age of household members, average educational level of household members, female to male ratio, year dummies for 2006, 2007 and 2008 (year 2005 as reference) regional dummies for Gjakove, Gjilan, Mitrovice, Peje, Prishtine, Prizren (region Ferizaj as reference), number of crops grown, % of crop output marketed, Simpson index, car ownership</p>	2152	4	Inverse variance	4	10

$W_i$ : treatment condition,  $Y_i$ : indicator variable,  $N$ : number of observations,  $C_i$ : covariates;  $M$ : number of matches,  $wm$ : weighting matrix,  $bc$ : bias-corrected;  $rm$ : number of robust matches.

**Table 5: Directional Output Distance Frontier Estimates**

Variable	Coefficient	t-statistics
Pepper output	1.17e-05***	6.34
Hay output	-1.22e-06**	-2.43
Tomato output	-6.42e-05***	-11.47
Onion output	-1.57e-04***	-27.71
Potato output	-8.07e-06***	-5.24
Land	5.43e-04	0.21
Labor ft (full-time)	0.002**	2.14
Labor pt (part-time)	0.006***	3.43
Machinery	-9.74e-07	-1.44
Fuel	2.04e-05*	1.80
Rentals (land/buildings)	-1.83e-05	-1.16
Fertilizers	4.24e-06**	2.30
Chemicals	2.82e-04***	5.80
Seeds	3.11e-06***	3.17
Pepper <sup>2</sup>	0.011***	5.40
Hay <sup>2</sup>	-0.002	-0.85
Tomato <sup>2</sup>	0.156***	14.66
Onion <sup>2</sup>	0.092***	9.05
Potato <sup>2</sup>	-8.07e-06***	-5.24
Land <sup>2</sup>	-8.85e-04***	4.61
Labor ft (full-time) <sup>2</sup>	-3.37e-04*	-1.90
Labor pt (part-time) <sup>2</sup>	-3.67e-04***	-8.52
Machinery <sup>2</sup>	-2.279e-04	-1.14
Fuel <sup>2</sup>	3.68e-05**	2.19
Rentals (land/buildings) <sup>2</sup>	-2.87e-05	-0.14
Fertilizers <sup>2</sup>	1.91e-04***	3.17
Chemicals <sup>2</sup>	-6.31e-04***	-7.00
Seeds <sup>2</sup>	-0.002***	-3.34
Hay * pepper	-0.028*	-1.83
Hay * tomato	-0.007	-0.27
Hay * onion	0.057**	2.15
Hay * potato	-0.033**	-2.78
Pepper * tomato	0.004	0.38
Pepper * onion	-0.053***	-3.02
Pepper * potato	0.023***	4.56
Tomato * onion	-0.183***	-9.18
Tomato * potato	-0.009	-0.98
Onion * potato	-0.035***	-6.04
Land * labor ft	-0.003*	-1.84
Land * labor pt	-0.002	-0.83
Land * machinery	-0.008***	-3.76
Land * fuel	-0.002***	4.34
Land * rentals	0.002	0.58
Land * fertilizers	0.005*	1.81
Land * chemicals	-0.002	-1.07
Land * seeds	-2.32e-04***	-9.20
Labor ft * labor pt	-1.46e-04***	-2.40
Labor ft * machinery	-0.002***	-2.34
Labor ft * fuel	0.001*	1.86
Labor ft * rentals	-9.05e-04	-1.06
Labor ft * fertilizer	9.81e-04	0.61
Labor ft * chemicals	-0.002***	-2.73
Labor ft * seed	-0.002***	-2.23
Labor pt * machinery	0.003**	2.27
Labor pt * fuel	0.001	1.08
Labor pt * rentals	-7.89e-04	-0.67
Labor pt * fertilizer	0.007***	3.23
Labor pt * chemicals	0.001	1.34
Labor pt * seed	-0.004	-3.29
Machinery * fuel	-5.04e-04	-0.96
Machinery * rentals	-0.001*	-1.80
Machinery * fertilizer	0.008***	5.29
Machinery * chemicals	-0.002***	-3.25
Machinery * seed	0.005***	5.20
Fuel * rentals	0.003***	3.55
Fuel * fertilizer	-0.002*	-1.97
Fuel * chemicals	2.56e-04	0.55
Fuel * seed	-0.002***	-4.15
Rentals * fertilizer	-0.003*	-1.80

Rentals * chemicals	1.89e-04	0.27		
Rentals * seed	-9.21e-04*	-1.81		
Fertilizer * chemicals	9.83e-04*	1.91		
Chemicals * seed	0.001**	2.51		
Hay * land	0.008**	2.22		
Hay * labor ft	0.003*	1.83		
Hay * labor pt	-0.002	-0.90		
Hay * machinery	0.006***	2.94		
Hay * fuel	0.001	0.57		
Hay * rentals	-8.51e-04	-0.39		
Hay * fertilizers	-0.017***	-4.34		
Hay * chemicals	0.006***	2.87		
Hay * seeds	0.012***	4.65		
Pepper * land	0.035***	3.30		
Pepper * labor ft	0.002*	1.91		
Pepper * labor pt	-0.038***	-10.63		
Pepper * machinery	0.007*	1.84		
Pepper * fuel	-0.003***	-2.73		
Pepper * rentals	0.008***	3.98		
Pepper * fertilizers	-0.021***	-8.64		
Pepper * chemicals	-0.005**	-2.28		
Pepper * seeds	-0.012***	-6.19		
Tomato * land	-0.306***	-9.59		
Tomato * labor ft	0.069***	9.24		
Tomato * labor pt	-0.087***	-6.48		
Tomato * machinery	0.128***	12.50		
Tomato * fuel	-0.121***	-14.50		
Tomato * rentals	-0.002	-0.18		
Tomato * fertilizers	0.006	0.63		
Tomato * chemicals	0.071***	12.15		
Tomato * seeds	-0.084***	-6.31		
Onion * land	0.252***	8.94		
Onion * labor ft	-0.093***	-11.97		
Onion * labor pt	0.138***	10.10		
Onion * machinery	-0.157***	-15.43		
Onion * fuel	0.146***	16.03		
Onion * rentals	-0.023*	-1.93		
Onion * fertilizers	-0.032***	-3.03		
Onion * chemicals	-0.049***	-11.09		
Onion * seeds	0.067***	5.20		
Potato * land	0.026**	2.41		
Potato * labor ft	0.030***	11.92		
Potato * labor pt	-0.023***	-6.58		
Potato * machinery	0.021***	7.07		
Potato * fuel	-0.027***	-13.25		
Potato * rentals	0.024***	7.18		
Potato * fertilizers	0.055***	12.87		
Potato * chemicals	-0.023***	-17.16		
Potato * seeds	0.021***	14.25		
Time	0.002*	1.90		
Time * time	-1.02e-04***	-13.57		
Constant	0.011**	2.31		
Technical efficiency	Mean	Std.dev.	Min	Max
Full sample	0.611***	0.243	0.012	0.981
Households with no migration	0.644***	0.231	0.012	0.981
Households with migration	0.571***	0.251	0.032	0.978
Gamma	0.819***			
Sigma	0.00596***			
Sigma-squared (v)	0.00108			
Sigma-squared (u)	0.00488			
Log likelihood function	3498.377			
Number of observations = 2163				

\*10%, \*\*5%, \*\*\*1% significance.



**Table 6: Determinants of Inefficiency**

Determinant	Coefficient	t-statistic
Migration Intensity (% of total available work time per household, per year)	0.729***	3.26
Migration Intensity * Migration Intensity	1.186***	4.06
Migration Intensity * Educational Level of Household Members	0.061***	6.93
Migration Intensity * Average Age of Household Members	0.011***	3.61
Migration Intensity * Female-to-Male-Ratio	0.178**	2.12
Migration Intensity * Total Income	0.000	3.09
Migration Intensity * Cattle	-0.093	-1.07
Migration Intensity * Farm Equipment	0.000	0.60
Average Educational Level of Household Members	-0.219***	-3.93
Average Age of Household Members	0.051***	7.71
Educational Level of Household Head	-0.254***	-11.23
Age of Household Head	0.018***	6.40
Female-to-Male Ratio	0.083*	1.94
Farm Equipment / Machinery	-0.000***	-18.73
Total Income	0.000	-0.47
Cattle	0.025	1.11
Children-to-Adult Ratio	0.372***	3.10
Simpson Index (SI)	11.739***	22.68
Number of Plots	0.457***	23.44
Product Diversity Index	0.031***	3.39
Region Ferizai	-0.283***	-2.19
Region Prizren	-0.578***	-5.49
Region Gjakove	-0.684***	-5.21
Region Peje	-0.350***	-3.05
Region Mitrovice	0.492***	4.15
Region Prishtine	-0.789***	-6.51
Year 2006	-0.301***	-3.02
Year 2007	-0.979***	-9.56
Year 2008	-0.314***	-3.31
Constant	9.998***	19.99

\*10%, \*\*5%, \*\*\*1% significance; benchmark year: 2005; benchmark region: Gjilan

**Table 7: Sample Average Treatment Effects (SATE) for Different Levels of Migration Intensity**

Migration Intensity (% of total available work time per hh and year used by migrants)	Change in Technical Efficiency due to Migration at Household Level (SATE)		
	mean	min	max
0% >= 5%	-0.143***	-0.249	-0.036
5% >= 10%	-0.023**	-0.062	-0.052
10% >= 15%	-0.058*	-0.123	0.006
15% >= 20%	-0.032	-0.009	0.025
20% >= 30%	-0.037**	-0.086	0.012
30% >= 40%	-0.012	-0.065	0.042
40% >= 50%	-0.057**	-0.131	-0.002
50% >= 60%	0.015	-0.074	0.104
60% >= 90%	-0.183***	-0.297	-0.071
Migration (Yes/No)	-0.042***	-0.065	-0.018

\*, \*\*, \*\*\* - significant at 10, 5, 1% level based on AI robust standard errors.

**Table 8: Robustness Checks for Matching Models (Exemplary for Migration [Yes/No])**

Distance Tolerance <i>(Limit Imposed for Distance)</i>	Treatment Effect		Overlap Check <i>(# of observations that violate the overlap assumption)</i>
	Coefficient	AI Robust Std. Err.	
Distance Metric I: Mahalanobis <i>(inverse sample covariate covariance)</i>			
0.0005	-0.042***	0.012	0
0.005	-0.041***	0.011	0
0.05	-0.041***	0.011	0
0.5	-0.046*	0.024	0
1.0	-0.047***	0.013	0
Distance Metric II: Inverse Variance <i>(inverse diagonal sample covariate covariance)</i>			
0.0005	-0.039***	0.011	0
0.005	-0.039***	0.012	0
0.05	-0.041***	0.012	0
0.5	-0.051*	0.027	0
1.0	-0.049***	0.013	0
Distance Metric III: Euclidean <i>(identity)</i>			
0.0005	-0.051***	0.011	0
0.005	-0.051***	0.010	0
0.05	-0.051***	0.011	0
0.5	-0.051*	0.026	0
1.0	-0.058*	0.031	0

\*, \*\*, \*\*\* - significant at 10, 5, 1% level.

Similar robustness checks for all other estimated treatments with respect to migration shares confirm the statistical quality of the estimated migration effects. These are not reported here due to limitations of space.

**Figure 1: Density Distribution of Technical Efficiency Scores**

