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How Off-farm Employment Affects Technical Efficiency of China's Farms: The Case of Jiangsu

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Abstract

Using three-wave survey data for four villages of Jiangsu Province in China, the present paper examines whether and to what extent off-farm employment affects the technical efficiency of agricultural production. The level of technical efficiency is measured using a stochastic frontier production function approach. Based on estimation results from instrumental variable panel quantile regressions we find that there is a positive significant effect of off-farm employment on the level of farm technical efficiency. We also find that fragmentation of farmland is a barrier to the improvement of technical efficiency. In addition, we find a downward trend in the level of agricultural technical efficiency among our sample. Therefore, the Chinese Government should stimulate agricultural mechanization and the development of farming techniques to improve technical efficiency in the context of increasing off-farm employment.

Key words: off-farm employment, stochastic frontier analysis, technical efficiency
JEL codes: O12, Q13, Q16

I. Introduction

Rapidly increasing off-farm employment may not only profoundly affect economic development of the non-agricultural sector, but also influence intra-household resource

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allocation in agricultural production (Cai, 2015; Qiao, 2015), especially in terms of food security. Pressure on food security arises due to the fact that on-farm labor supply decreases as off-farm employment increases (Pfeiffer *et al*., 2009). In addition, rapid urbanization increases demand for land and water, which are essential factors of agricultural production (Chen, 2007). Therefore, decreasing on-farm labor supply and increased demand for land and water resources may have negative effects on food supply. Increases in off-farm employment also increase food demand, especially the demand for grain among off-farm employees who live in urban areas (Christiansen, 2009). To face these pressures arising from increased food demand and a possible decrease in food supply, Chinese farms should improve their long-run technical efficiency (Yao and Liu, 1998).

To address imminent pressures on food security, it is of great importance to understand the determinants of agricultural technical efficiency, especially in light of the increasing number of off-farm employees in rural areas. In other words, the development of off-farm employment may play a significant role in determining the level of agricultural technical efficiency. However, most studies of the impact of off-farm employment have been concerned with its impact on agricultural fixed assets (Takahashi and Otsuka, 2009; Su *et al*., 2015), renting of land (Kung, 2002; Deininger and Jin, 2005; Ji *et al*., 2016) and time allocation of on-farm labor (Chang *et al*., 2011; Mu and van de Walle, 2011). The impact of off-farm employment on agricultural technical efficiency has received less attention.

The majority of studies on the impact of off-farm employment on technical efficiency have been conducted in countries other than China and the results are mixed. A number of studies from African countries find that off-farm employment has a positive effect on technical efficiency in terms of off-farm income (Mochebelele and Winter-Nelson, 2000; Kibaara, 2005; Tijani, 2006; Haji, 2007; Essilfie *et al*., 2011). At the same time, studies from Europe and North America show that technical efficiency is negatively related to off-farm employment in terms of off-farm income and labor (O'Neill and Matthews, 2001; Goodwin and Mishra, 2004; Yee *et al*., 2004). In addition, some other studies find no significant association between technical efficiency in terms of off-farm income and off-farm labor (Chavas *et al*., 2005; Bozoğlu and Ceyhan, 2007; Chang and Wen, 2011).

Thus, to date, no consensus has been reached on the effect of off-farm employment on technical efficiency. This could be due to at least three factors. First, it could be attributed to the differences in the institutional set up of agricultural production in Africa, Europe, North America and Asia. Second, it may be that these studies employed different methods to measure technical efficiency. Finally, a reverse-causal relationship may exist between off-farm employment and technical efficiency, a possibility that has largely been ignored.

In the present study, we attempt to examine the impact of off-farm employment on agricultural technical efficiency within the setting of rural China. The present paper offers contributions to the published literature in two dimensions. First, we measure the level of agricultural technical efficiency and describe its distribution. Second, we examine the effect of off-farm employment on the level of agricultural technical efficiency. Estimates of the extent of technical efficiency will help to assess whether improving efficiency or developing new technologies to raise agricultural productivity are appropriate responses to increasing off-farm employment. Moreover, understanding the relationship between off-farm employment and agricultural technical efficiency also has policy implications for agricultural development arising concurrently with urbanization.

The remainder of the paper proceeds as follows. Section II provides a brief introduction of the data used and definitions of the key variables. Section III describes the method for measuring technical efficiency and the econometric methodology for estimating the impact of off-farm employment on both the level of and changes in agricultural technical efficiency. Section IV presents the results and Section V concludes.

II. Data and Key Variables

The data used in our study come from the past three rounds of an agricultural household survey conducted in four villages of Jiangsu Province (Jiangsu Agricultural Household Survey, JAHS). The data were collected by the Center for Chinese Agricultural Policy of the Chinese Academy of Sciences in 2003, 2007 and 2011. The first round was conducted in 1988. For more details on the exact survey process, please see Ye and Rozelle (1994). After omitting observations that lacked household farming activities and accounting for sample attrition, we have a three-wave balanced panel dataset of 69 agricultural households containing information from years 2002, 2006 and 2010.

The sample area of the JAHS is typical of rural areas in eastern and central China, which contain well-developed agricultural infrastructure and a rapidly developing rural industrial base. In addition, off-farm employment is common as a consequence of a great number of industrial firms in Jiangsu Province. Therefore, the results from this study have implications for other regions as well, especially for the rapidly developing rural areas of central and western China that are in the midst of urbanization and industrialization.

In terms of survey questions on agricultural production, the JAHS asked farmers what kind of crops households are growing and about the associated inputs and outputs of production. In the survey questionnaires, these crops include rice, wheat, other coarse grains, buckwheat, maize, cotton, other grain, potato, soybean, rapeseed, mulberry leaf and vegetables. In the survey region of Jiangsu Province, the normal cropping system is double cropping, for which households plant rice during the period from spring to fall and then plant wheat or rapeseed during the period from fall to the following spring. According to our data, the proportions of households who harvest wheat and rapeseed in spring are approximately 83 and 14 percent, respectively, while 88 percent of households harvest rice in fall. Obviously, compared to these three kinds of crops, planting scales for other crops are very small. In addition, from the village questionnaire, we have price information on rice, wheat and rapeseed. We define agricultural output as the aggregated output value of rice, wheat and rapeseed.

Besides output in the agricultural sector, the JAHS also collected information on agricultural inputs, such as farmland size, labor (measured as days of farming times for crops, including days of work by family members and hired labor), and capital (agricultural fixed assets, flexible inputs and expenditure on agricultural services). Agricultural fixed assets include draft animals, agricultural machines and tools for agricultural transport. Flexible inputs include expenditure on seeds, fertilizers, pesticides and herbicides. Expenditure on agricultural services is represented by the expenditure for purchases of machinery services for cultivation and harvest. Table 1 presents the summary statistics of the agricultural inputs and outputs discussed in our study.

Table 1. Summary Statistics of Agricultural Inputs and Outputs

Variable	Description	2002		2006		2010	
		Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
Output	Aggregate output value (yuan)	3042	1190	3956	8817	3086	1201
Land	Farmland size (mu)	6.52	4.80	8.09	10.69	5.94	2.49
Labor	Days of farming times	105.3	67.76	106.8	86.03	82.82	79.10
Capital	Capital input (yuan)	4034	19 240	4145	9476	3691	5814
	Number of observations	69		69		69	

Source: Authors' survey.

Notes: In computing the value of aggregate output we take the price of rice, wheat and rapeseed in 2002 as the price of the three kinds of crops across the whole study period. 1 mu = 1/15 ha.

III. Method and Model

We use stochastic frontier analysis to estimate agricultural technical efficiency for two reasons. First, the estimated result reports the coefficient estimates, which reflect the elasticity of the agricultural input on output. Second, it is straightforward to estimate agricultural technical efficiency and conduct econometric regressions for stochastic frontier analysis using Stata 13 statistical software. A stochastic frontier production function is comprised of a translog production function of the normal multivariate regression type with two error terms (Aigner *et al*., 1977; Meeusen and van de Broeck, 1977). The first error term represents the effect of statistical noise(e.g. measurement error). The second error term captures systematic influences that are unexplained by the production function and are attributed to the effect of technical inefficiency. The stochastic frontier production function is specified as follows:

$$Log(Q_{it}) = \beta Log(X_{it}) + V_{it} - U_{it}\ , \tag{1}$$

$$TE_{it} = \exp(-U_{it})\ , \tag{2}$$

where i is an index for the ith agricultural household and t denotes time (year). The terms Q_{it} and X_{it} are vectors of agricultural output and inputs, respectively, shown in Table 1. The statistical noise error term, V_{it}, is assumed to be normally distributed, with $E[V_{it}] = 0$ and $\mathrm{Var}[V_{it}] = \delta_v^2$. U_{it} is half-normally distributed for the inefficiency term with $U_{it} > 0$. Therefore, TE represents the agricultural efficiency with $0 < TE < 1$.

To examine the effects of off-farm employment on technical efficiency, we specify the following empirical model with reference to the literature review on determinants of technical efficiency in the later paragraphs of this section:

$$TE_{it} = \alpha_1 + \gamma_1 OFE_{it} + \beta_1 X_{it} + \varepsilon_{it}\ , \tag{3}$$

where TE_{it} is computed according to Equations (1) and (2). OFE_{it} is off-farm employment, which is the main independent variable of interest. The term X_{it} is a vector of covariates that are included to capture the characteristics of households. Throughout our analysis, X_{it} also includes a set of year dummy variables. ε_{it} is the random error term.

According to previous studies, there are many other determinants that can affect the level of agricultural technical efficiency. Zhou *et al*. (2011) find that different agricultural public investments influence the level of technical efficiency at province or county level. Several studies also document that farmland size and farmland fragmentation are associated with the level of agricultural technical efficiency (Helfand and Levine, 2004; Rios and Shively, 2005; Rahman and Rahman, 2009). Some other determinants related to land include fertility of the soil and distance from the land plot to the nearest road (Binam *et al*., 2004; Tan *et al*., 2010). The socioeconomic and demographic characteristics of family members were also identified as correlates, including social capital, education, health, farming experience and household head characteristics (Wang *et al*., 1996; Liu and Zhuang, 2000; Ajani and Ugwu, 2008). In addition, Gorton and Davidova (2004) show that, when comparing the level of technical efficiency between agricultural households and agricultural companies, production efficiency is associated with the type of production organization. Other agricultural input factors have been examined, such as agricultural finance credits (Parikh and Shah, 1994; Binam *et al*., 2004).

Based on previous research and the nature of our dataset, we choose to include the relevant factors as controls (X_{it}), shown in Table 2. The shares of farming time by female and elderly family members are intended to capture the gender and age structure of the agricultural labor input. The number of farmland plots and farmland size per capita represent different dimensions of farmland characteristics. The number of farmland plots measures the extent of farmland fragmentation, while farmland size per capita reflects farmland scale. The number of family members with at least junior high school education reflects the educational level of individual households. This can affect the family's probability of adopting new agricultural technologies. We also include two characteristics of the household head: age and education level.

Table 2. Summary Statistics of Determinants of Technical Efficiency

Variables	2002		2006		2010	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
Number of off-farm labor (persons)	1.62	0.96	2.00	1.12	2.30	1.14
Share of farming time by women	0.61	0.18	0.44	0.30	0.49	0.38
Share of farming time by elderly	0.06	0.21	0.27	0.40	0.43	0.48
Number of farmland plots	4.07	1.61	4.25	2.43	3.29	1.90
Farmland size per capita (mu)	1.89	1.30	2.22	2.70	1.70	1.12
Number of members with at least junior school education (persons)	0.36	0.59	0.46	0.83	0.64	0.94
Age of household head (years)	49.43	9.80	54.06	9.37	57.22	8.92
Educational level of household head (years)	5.88	3.72	5.65	3.95	5.90	4.21
Number of observations	69		69		69	

Source: Authors' survey.

Note: 1 mu = 1/15 ha.

As can be seen from Table 2, some of the independent variables display a time trend. For example, the number of off-farm employees in the household increases from 1.62 persons in 2002 to 2.30 persons in 2010. In addition, the considerable increase in the share of farming time for elderly members indicates an aging trend of the agricultural labor input. A similar increasing trend can be observed for the number of household members with at least a junior high school education and for the age of the household head. For example, in 2010 there is, on average, less than one person per household with at least a junior high school education. However, there are no visible time trends in the number of farmland plots, the farmland size per capita and the education level of household heads.

The empirical specification above does not recognize the possible presence of endogeneity stemming from reverse causality between off-farm employment and technical efficiency. That is, the number of off-farm employees in a household may increase due to improvements in agricultural technical efficiency. To account for the potential endogeneity of off-farm employment, we adopt an instrumental variable (IV) approach. Specifically, following previous studies (Démurger and Li, 2012; Hu, 2012), we use the migrant network as an IV for off-farm employment. The migrant network is measured by the average number of households other than the household under discussion in the same village that have household members participating in off-farm employment in the previous year. We assume that the migrant network is correlated with off-farm employment but has no direct effect on technical efficiency at the household level.

IV. Empirical Results

1. Estimates of Level of Technical Efficiency

Following Belotti *et al*. (2013), the parameters of the stochastic translog production function in Equation (1) and the level of technical efficiency in Equation (2) are estimated with Stata 13. Table 3 presents the results of Equation (1). The estimated coefficients of the translog production function can be interpreted as production elasticities. As the results show, the labor elasticity is very small (0.01) and statistically insignificant. In contrast, the value of output elasticities for land and capital are 0.41 and 0.16, respectively, and both are statistically significant at the 1-percent level. This indicates that a-percentage change in inputs results in less percentage change in outputs.

Table 3. Results from Stochastics Frontier Analysis

Variable	Coefficient	Standard error
Ln(land)	0.41***	0.07
Ln(labor)	0.01	0.04
Ln(capital)	0.16***	0.05
Constant	6.27***	0.32
Number of observations	207	

Source: Authors' survey.

Note: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Based on the estimations provided by Equation (2), we compute the level of agricultural technical efficiency for each agricultural household and year. Table 4 presents the summary statistics of the technical efficiency estimates. The technical efficiencies exceed 0.5 for 94.9 percent ((217–3–5–3)/217*100% = 94.9%) of the household farms in the sample and most of them are in the 0.7–0.9 interval. The average values of agricultural technical efficiency in 2002, 2006 and 2010 are 0.77, 0.72 and

0.75, respectively, which are slightly lower than the values found in a previous study in Jiangxi Province for the year 2002 (Feng, 2008). The distribution of technical efficiency is clearly right-skewed (see Figure 1). There appears to be no time trend in the average level of technical efficiency. This indicates that further empirical research is needed to better understand technical efficiency.

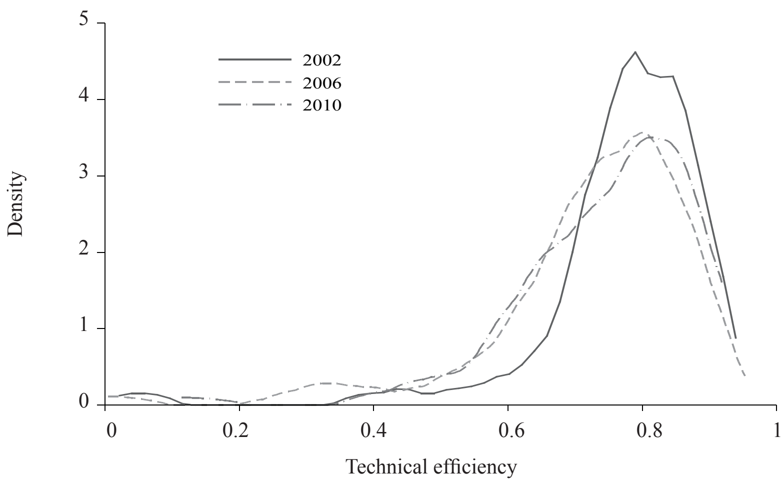
Table 4. Summary Statistics of Technical Efficiency

Efficiency	2002	2006	2010
	Number of households with technical efficiency in different intervals		
TE < 0.5	3	5	3
0.5 ≤ *TE* < 0.6	2	4	3
0.6 ≤ *TE* < 0.7	5	15	14
0.7 ≤ *TE* < 0.8	24	20	20
0.8 ≤ *TE* < 0.9	33	23	26
0.9 ≤ *TE*	2	2	3
Mean	0.77	0.72	0.75
Standard deviation	0.13	0.16	0.13
Minimum	0.05	0.00	0.11
Maximum	0.91	0.95	0.92
Number of observations	69	69	69

Source: Authors' survey.

Note: *TE*, technical efficiency.

Figure 1. Distribution of Agricultural Technical Efficiency on the Basis of Kernel Density Estimates by Year



Notes: Kernel = epanechnikov; bandwidth = 0.0304.

In terms of changes in technical efficiency, we find that the number of households with decreasing technical efficiency is greater than that of those with increasing technical efficiency from 2002 to 2006. However, the opposite pattern is observed for the period 2006 to 2010 (see Table 5). This is also reflected in the mean values of technical efficiency for the 3 sample years.

Table 5. Change in Technical Efficiency

Status	2002–2006	2006–2010
Decreased	44	32
No change	0	0
Increased	25	37
Number of observations	69	69

Source: Authors' survey.

When we examine the relationship between off-farm employment and the value of agricultural technical efficiency, we find that in 2002 and 2010 the mean values of agricultural technical efficiency for the households with off-farm employees are higher than for those without members in off-farm work (see Table 6). However, the opposite is found to be true in 2006. Therefore, it is not obvious from the results of a simple descriptive analysis whether any correlation exists between off-farm employment and agricultural technical efficiency. Next, we examine whether a clear correlation emerges once other factors are taken into account.

Table 6. Summary Statistics of Technical Efficiency by Off-farm Employment

	2002	2006	2010
Farms with off-farm workers	0.772	0.721	0.753
Farms without off-farm workers	0.764	0.759	0.651
Number of observations	69	69	69

Source: Authors' survey.

2. Determinant of the Farms' Technical Efficiency

Because of the skewed distribution of the level of technical efficiency, we use the IV panel general least square (GLS) model to estimate the determinants of technical efficiency. As discussed above, we employ an IV method with the migrant network variable as the instrument. The regression estimates from the first stage are reported in the first column of Table 7. These estimates suggest that there is a strong correlation between off-farm employment and migrant networks. In the second stage of estimation, we use the predicted values of off-farm employment as the IV for off-farm employment. The estimates are reported in columns 2 to 5 of Table 7.

According to the panel GLS estimates, there is a significant positive effect of off-farm employment on technical efficiency. The effect is sizable; technical efficiency increases by 0.10 for every additional household member that participates in off-farm employment. The positive effect of off-farm employment on technical efficiency is expected because the households with off-farm employees are more likely to adopt new technologies and agricultural machinery (Ji *et al*., 2012).

Table 7. Estimation Results of Determinants of Technical Efficiency

Variable	First stage	Panel	Quantile regressions		
	Off-farm employment	general least square	25% quantile	50% quantile	75% quantile
	(1)	(2)	(3)	(4)	(5)
Migrant network	0.69***				
	(0.20)				
Size of off-farm workforce		0.10**	0.14***	0.08*	0.05*
		(0.05)	(0.05)	(0.04)	(0.03)
Share of farming time by females	0.16	0.02	–0.00	0.02	–0.01
	(0.24)	(0.03)	(0.04)	(0.03)	(0.02)
Share of farming time by elderly	–0.50**	0.04	0.05	0.05	0.02
	(0.22)	(0.04)	(0.05)	(0.03)	(0.02)
Number of farmland plots	0.05	–0.03***	–0.04***	–0.03***	–0.03***
	(0.04)	(0.01)	(0.01)	(0.01)	(0.00)
Farmland area per capita	–0.09**	0.01	–0.01	0.02	0.01**
	(0.04)	(0.01)	(0.02)	(0.01)	(0.01)
Number of members with at least junior school education	0.30***	–0.02	–0.05	–0.00	0.00
	(0.11)	(0.02)	(0.03)	(0.02)	(0.01)
Head's age	0.01	0.00	0.00	0.00	0.00
	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)
Head's educational level	0.00	0.00	0.00	0.00	–0.00
	(0.02)	(0.00)	(0.00)	(0.00)	(0.00)
Year_2006		–0.07***	–0.09***	–0.07***	–0.05***
		(0.03)	(0.03)	(0.02)	(0.01)
Year_2010		–0.10***	–0.11***	–0.09***	–0.07***
		(0.03)	(0.04)	(0.03)	(0.02)
Constant	0.30	0.56***	0.55***	0.72***	0.79***
	(0.63)	(0.09)	(0.18)	(0.09)	(0.05)
Number of observations	207	207		207	

Source: Authors' survey.

Notes: Standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

In addition to the main independent variable in Table 7, several other variables have a significant effect on agricultural efficiency. First, the coefficient on the number of farmland plots is negative and statistically significant, which implies that the more fragmented the farmland is, the lower is the level of technical efficiency. This result is consistent with the results that Foster and Rosenzweig (2010) found for India. In addition, the effect size is not small considering the fact that, on average, household farms have four plots of land. Second, the significant negative coefficient estimates on the year dummy variables for 2006 and 2010 imply that there is a decreasing time trend in agricultural efficiency when controlling for all other independent variables. The negative time effects are approximately the same magnitude as the positive effect of household engagement in off-farm employment: in other words, not small. The significantly negative downward trend in technical efficiency indicates a major food security issue in Jiangsu Province. We do not observe a decline in technical efficiency in the sample of farms on average, but these results are still concerning. Although we have very limited information on potential causes, one possibility could be increased pollution of water and soil. This is an important topic and warrants further research.

These results also show that the shares of farming time completed by female and elderly household members have no significant effect on technical efficiency. As in de Brauw *et al*. (2013), the estimates imply that agricultural feminization and aging have no negative effects on agricultural output. One plausible explanation for the neutral effect of agricultural feminization and aging is the increased adoption of new farming techniques.

To examine the robustness of the effect of off-farm employment on the level of technical efficiency, we ran IV quantile regressions for the determinants of technical efficiency. According to the results in Table 7, the estimates for the different quantiles are qualitatively similar to those of the IV panel GLS (see row 2 of Table 7). The estimated impact of having an additional household member involved in off-farm employment on agricultural technical efficiency is, as expected, lower for the higher quantiles. This result suggests that off-farm employment has a larger effect on farms with lower levels of agricultural technical efficiency.

V. Conclusions

In this study we estimated the technical efficiency of household farms using a panel dataset from rural areas of Jiangsu Province and examined the effect of off-farm employment on the technical efficiency of farms, controlling for a host of other possible determinants. Unlike earlier studies, we account for the endogeneity of migration behavior by using an IV estimation strategy. We find robust evidence that off-farm employment significantly increases technical efficiency at the household level in both statistical and economic terms. The estimates also show that fragmentation of farmland has a sizable negative impact on technical efficiency.

The effects of off-farm employment on technical efficiency have important policy implications. First, the positive effect of off-farm employment on technical efficiency suggests that industrialization and urbanization contribute to improvements in agricultural technical efficiency in addition to the creation of more off-farm employment opportunities. Moreover, off-farm employment is helpful for agricultural technological dissemination, especially in the case of return migration to farms. Off-farm employment also impels agricultural mechanization as the result of labor substitution.

Two factors are found not to affect farms' technical efficiency levels. The proportion of women and elderly individuals in the farm workforce do not influence technical efficiency of agricultural production. This is good news as the aging and feminization of farm labor is expected to continue. However, when controlling for several determinants, we also find that there is a downward trend in technical efficiency at the household farm level. Although in terms of aggregate average numbers there is no decline (due to counteracting factors), this finding still has concerning implications for future food security.

Our findings also have some important policy implications. First, these results reflect that the trend of urbanization and off-farm employment in China appear to have a positive effect on agricultural technical efficiency. Second, our results suggest that the Chinese Government should encourage farmland centralization due to the negative impacts farmland fragmentation can have on agricultural technical efficiency. Third, although the feminization and aging of agricultural on-farm labor does not appear to be a major challenge, efforts should be made to improve agricultural extension services, social security and welfare support to older farmers. Finally, Chinese Government policies should provide incentives to rural households to make use of microfinance and to participate in off-farm employment sectors that can help increase technical efficiency in agriculture. In addition, future research would benefit from access to nationally representative data.

References

Aigner, D., C. K. Lovell and P. Schmidt, 1977, "Formulation and estimation of stochastic frontier production function models," *Journal of Econometrics*, Vol. 6, No. 1, pp. 21–37.

Ajani, O. I. Y. and P. C. Ugwu, 2008, "Impact of adverse health on agricultural productivity of farmers in Kainji Basin, north central Nigeria using a stochastic production frontier approach," *Trends in Agriculture Economics*, Vol. 1, No. 1, pp. 1–7.

Belotti, F., S. Daidone, G. Ilardi and V. Atella, 2013, "Stochastic frontier analysis using Stata," *The Stata Journal*, Vol. 13, No. 4, pp. 719–58.

Binam, J. N., J. Tonyè, N. Wandji, G. Nyambi and M. Akoa, 2004, "Factors affecting the technical efficiency among smallholder farmers in the slash and burn agriculture zone of Cameroon," *Food Policy*, Vol. 29, No. 5, pp. 531–45.

Bozoğlu, M. and V. Ceyhan, 2007, "Measuring the technical efficiency and exploring the inefficiency determinants of vegetable farms in Samsun province, Turkey," *Agricultural Systems*, Vol. 94, No. 3, pp. 649–56.

Cai, F., 2015, "Haste makes waste: Policy options facing China after reaching the Lewis turning point," *China & World Economy*, Vol. 23, No. 1, pp. 1–20.

Chang, H. H. and F. I. Wen, 2011, "Off-farm work, technical efficiency, and rice production risk in Taiwan," *Agricultural Economics*, Vol. 42, No. 2, pp. 269–78.

Chang, H. Q., X. Y. Dong and F. MacPhail, 2011, "Labor migration and time use patterns of the left-behind children and elderly in rural China," *World Development*, Vol. 39, No. 12, pp. 2199–210.

Chavas, J. P., R. Petrie and M. Roth, 2005, "Farm household production efficiency: Evidence from the Gambia," *American Journal of Agricultural Economics*, Vol. 87, No. 1, pp. 160–79.

Chen, J., 2007, "Rapid urbanization in China: A real challenge to soil protection and food security," *CATENA*, Vol. 69, No. 1, pp. 1–15.

Christiansen, F., 2009, "Food security, urbanization and social stability in China," *Journal of Agrarian Change*, Vol. 9, No. 4, pp. 548–75.

de Brauw, A., J. K. Huang, L. X. Zhang and S. Rozelle, 2013, "The feminisation of agriculture with Chinese characteristics," *Journal of Development Studies*, Vol. 49, No. 5, pp. 689–704.

Deininger, K. and S. Q. Jin, 2005, "The potential of land rental markets in the process of economic development: Evidence from China," *Journal of Development Economics*, Vol. 78, No. 1, pp. 241–70.

Démurger, S. and S. Li, 2012, "Migration, remittances and rural employment patterns: Evidence from China," *Groupe d'Analyse et de Théorie Economique Working Paper* No. 1230 [online; cited 13 October 2015]. Available from: http://dx.doi.org/10.2139/ssrn.2165790.

Essilfie, F. L., M. T. Asiamah and F. Nimoh, 2011, "Estimation of farm level technical efficiency in small scale maize production in the Mfantseman municipality in the central region of Ghana: A stochastic frontier analysis," *Journal of Development and Agricultural Economics*, Vol. 3, No. 14, pp. 645–54.

Feng, S. Y., 2008, "Land rental, off-farm employment and technical efficiency of farm households in Jiangxi Province, China," *NJAS-Wageningen Journal of Life Sciences*, Vol. 55, No. 4, pp. 363–78.

Foster, A. and M. R. Rosenzweig, 2010, "Barriers to farm profitability in India: Mechanization, scale and credit markets," Paper Presented at the Conference Agriculture for Development – Revisited, University of California at Berkeley, CA, 1–2 October.

Goodwin, B. K. and A. K. Mishra, 2004, "Farming efficiency and the determinants of multiple job holding by farm operators," *American Journal of Agricultural Economics*, Vol. 86, No. 3, pp. 722–29.

Gorton, M. and S. Davidova, 2004, "Farm productivity and efficiency in the CEE applicant countries: A synthesis of results," *Agricultural Economics*, Vol. 30, No. 1, pp. 1–16.

Haji, J., 2007, "Production efficiency of smallholders' vegetable-dominated mixed farming system in eastern Ethiopia: A non-parametric approach," *Journal of African Economies*, Vol. 16, No. 1, pp. 1–27.

Helfand, S. M. and E. S. Levine, 2004, "Farm size and the determinants of productive efficiency in the Brazilian center–west," *Agricultural Economics*, Vol. 31, No. 2–3, pp. 241–49.

Hu, F., 2012, "Migration, remittances, and children's high school attendance: The case of rural China," *International Journal of Educational Development*, Vol. 32, No. 3, pp. 401–11

Ji, X. Q., S. Rozelle, J. K. Huang, L. X. Zhang and T. L. Zhang, 2016, "Are China's farms growing?" *China & World Economy*, Vol. 24, No. 1, pp. 41–62.

Ji, Y. Q., X. H. Yu and F. N. Zhong, 2012, "Machinery investment decision and off-farm employment in rural China," *China Economic Review*, Vol. 23, No. 1, pp. 71–80.

Kibaara, B. W., 2005, "Technical efficiency in Kenyan's maize production: An application of the stochastic frontier approach," Doctoral dissertation, Colorado State University [online; cited 13 October 2015]. Available from: http://fsg.afre.msu.edu/kenya/o_papers/tech_eff_maize.pdf.

Kung, J. K. S., 2002, "Off-farm labor markets and the emergence of land rental markets in rural China," *Journal of Comparative Economics*, Vol. 30, No. 2, pp. 395–414.

Liu, Z. N. and J. Z. Zhuang, 2000, "Determinants of technical efficiency in post-collective Chinese agriculture: Evidence from farm-level data," *Journal of Comparative Economics*, Vol. 28, No. 3, pp. 545–64.

Meeusen, W. and J. van den Broeck, 1977, "Efficiency estimation from Cobb-Douglas production functions with composed error," *International Economic Review*, Vol.18, No. 2, pp. 435–44.

Mochebelele, M. T. and A. Winter-Nelson, 2000, "Migrant labor and farm technical efficiency in Lesotho," *World Development*, Vol. 28, No. 1, pp. 143–53.

Mu, R. and D. van de Walle, 2011, "Left behind to farm? Women's labor re-allocation in rural China," *Labour Economics*, Vol. 18, No. S1, pp. 83–97.

O'Neill, S. and A. Matthews, 2001, "Technical change and efficiency in Irish agriculture," *Economic and Social Review*, Vol. 32, No. 3, pp. 263–84.

Parikh, A. and K. Shah, 1994, "Measurement of technical efficiency in the northwest frontier province of Pakistan," *Journal of Agricultural Economics*, Vol. 45, No. 1, pp. 132–38.

Pfeiffer, L., A. López-Feldman and J. E. Taylor, 2009, "Is off-farm income reforming the farm? Evidence from Mexico," *Agricultural Economics*, Vol. 40, No. 2, pp. 125–38.

Rahman, S. and M. Rahman, 2009, "Impact of land fragmentation and resource ownership on productivity and efficiency: The case of rice producers in Bangladesh," *Land Use Policy,* Vol. 26, No. 1, pp. 95–103.

Qiao, F. B., S. Rozelle, L. X. Zhang, Y. Yao and J. Zhang, 2015, "Impact of childcare and eldercare on off-farm activities in rural China," *China & World Economy*, Vol. 23, No. 2, pp. 100–20.

Rios, A. R. and G. E. Shively, 2005, "Farm size and nonparametric efficiency measurements for coffee farms in Vietnam," *Technical Report* 19159, American Agricultural Economics Association, 2005 annual meeting, 24–27 July, Providence, RI [online; cited 13 October 2015]. Available from: http://ideas.repec.org/p/ags/aaea05/19159. html.

Su, W. L., C. F. Liu, L. X. Zhang, R. F. Luo and H. M. Yi, 2015, "Household-level linkages between off-farm employment and agricultural fixed assets in rural China," *China Agricultural Economic Review*, Vol. 7, No. 2, pp. 185–96.

Takahashi, K. and K. Otsuka, 2009, "The increasing importance of nonfarm income and the changing use of labor and capital in rice farming: The case of Central Luzon, 1979–2003," *Agricultural Economics*, Vol. 40, No. 2, pp. 231–42.

Tan, S. H., N. Heerink, A. Kuyvenhoven and F. T. Qu, 2010, "Impact of land fragmentation on rice producers' technical efficiency in South-East China," *NJAS – Wageningen Journal of Life Sciences*, Vol. 57, No. 2, pp. 117–23.

Tijani, A. A., 2006, "Analysis of the technical efficiency of rice farms in Ijesha Land of Osun State, Nigeria," *Agrekon*, Vol. 45, No. 2, pp. 126–35.

Wang, J. R., G. L. Cramer and E. J. Wailes, 1996, "Production efficiency of Chinese agriculture: Evidence from rural household survey data," *Agricultural Economics*, Vol. 15, No. 1, pp. 17–28.

Yao, S. J. and Z. N. Liu, 1998, "Determinants of grain production and technical efficiency in China," *Journal of Agricultural Economics*, Vol. 49, No. 2, pp. 171–84.

Ye, Q. L. and S. Rozelle, 1994, "Fertilizer demand in China's reforming economy," *Canadian Journal of Agricultural Economics*, Vol. 42, No. 2, pp. 191–207.

Yee, J., M. C. Ahearn and W. Huffman, 2004, "Links among farm productivity, off-farm work, and farm size in the Southeast," *Journal of Agricultural and Applied Economics*, Vol. 36, No. 3, pp. 591–603.

Zhou, X. B., K. W. Li and Q. Li, 2011, "An analysis on technical efficiency in post-reform China," *China Economic Review*, Vol. 22, No. 3, pp. 357–72.

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