Land rental market and rural household efficiency in China

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ONLINE APPENDIX

Appendix A. Measuring production efficiency

Estimating the efficiency indexes TE in (4) and AE in (6) requires knowing the underlying technology. Consider a sample of n observations of farm-households, where $(\boldsymbol{x}^j, \boldsymbol{F}^j, H^j, \boldsymbol{L}^j)$ is the vector of inputs and $(\boldsymbol{y}^j, N^j)$ is the vector of outputs chosen by the j-th farm household, $j = 1, \ldots, n$. Under feasibility, we have $(\boldsymbol{x}^j, \boldsymbol{F}^j, H^j, \boldsymbol{L}^j, \boldsymbol{y}^j, N^j) \in \boldsymbol{X}$, where $\boldsymbol{X}$ is the feasible set of household production activities.

These production data can be used to provide a representation of the technology $\boldsymbol{X}$. Two methods have been proposed in the literature. The first method involves the parametric specification and estimation of a stochastic production frontier (Kumbhakar and Lovell, 2003). The second method is nonparametric and involves the smallest set containing the observed inputs and outputs (e.g., Afriat, 1972; Varian, 1984; Färe *et al.*, 1985). The nonparametric method has also been called Data Envelopment Analysis (DEA) as it involves finding the tightest envelope of observed inputs and outputs. In this paper, we follow the nonparametric approach, where $\boldsymbol{X}$ is represented by the set

$$\boldsymbol{X}^e = \{(\boldsymbol{x}, \boldsymbol{F}, H, \boldsymbol{L}, \boldsymbol{y}, N) \colon \boldsymbol{y} \leq \Sigma_i \lambda_i \boldsymbol{y}^i, N \leq \Sigma_i \lambda_i N^i, \boldsymbol{x} \geq \Sigma_{\mathrm{i}} \lambda_i \boldsymbol{x}^i, \boldsymbol{F} \geq \Sigma_i \lambda_i \boldsymbol{F}^i,$$

$$H \geq \Sigma_i \lambda_i H^i, \boldsymbol{L} \geq \Sigma_i \lambda_i \boldsymbol{L}^i, \Sigma_i \lambda_i = 1, \lambda_i \geq 0, i = 1, \ldots, n\}.$$

The set $\boldsymbol{X}^e$ is closed and convex (Afriat, 1972; Varian, 1984). Using $\boldsymbol{X}^e$ as representation of technology, the technical efficiency index *TE* in (4) for the *j*-th farm-household is obtained by solving the linear programming problem

$$TE(\boldsymbol{x}^j, \boldsymbol{F}^j, H^j, \boldsymbol{L}^j, \boldsymbol{y}^j, N^j, \boldsymbol{X}^e) = 1/\max_{\gamma,\lambda} \{\gamma \colon \gamma \boldsymbol{y}^j \leq \Sigma_{\mathrm{i}} \lambda_i \boldsymbol{y}^i, \gamma N^j \leq \Sigma_{\mathrm{i}} \lambda_i N^i,$$

$$\boldsymbol{x}^j \geq \Sigma_{\mathrm{i}} \lambda_i \boldsymbol{x}^i, \boldsymbol{F}^j \geq \Sigma_{\mathrm{i}} \lambda_i \boldsymbol{F}^i, H^j \geq \Sigma_{\mathrm{i}} \lambda_i H^i, \boldsymbol{L}^j \geq \Sigma_i \lambda_i \boldsymbol{L}^i, \Sigma_{\mathrm{i}} \lambda_i = 1, \lambda_i \geq 0,$$

$$i = 1, \ldots, n\}. \qquad (4')$$

Similarly, from (5), the maximum revenue for the j-th household under the nonparametric representation $\boldsymbol{X}^e$ is obtained from the linear programming problem

$$R(\boldsymbol{p}, \boldsymbol{x}^j, H^j, \boldsymbol{L}^j, \boldsymbol{X}^e) = \max_{y,N,\lambda} \{\boldsymbol{p}'\boldsymbol{y} + N \colon \boldsymbol{y} \leq \Sigma_{\mathrm{i}}\, \lambda_i\, \boldsymbol{y}^i, N \leq \Sigma_{\mathrm{i}}\, \lambda_i\, N^i,$$

$$\boldsymbol{x}^j \geq \Sigma_{\mathrm{i}}\, \lambda_i\, \boldsymbol{x}^i, \boldsymbol{F}^j \geq \Sigma_{\mathrm{i}}\, \lambda_i\, \boldsymbol{F}^i, H^j \geq \Sigma_{\mathrm{i}}\, \lambda_i\, H^i, \boldsymbol{L}^j \geq \Sigma_i\, \lambda_i\, \boldsymbol{L}^i, \Sigma_{\mathrm{i}}\, \lambda_i = 1, \lambda_i \geq 0,$$

$$i = 1, \ldots, n\}. \qquad (5')$$

For each farm household, using $TE(\cdot)$ in (4′) and $R(\cdot)$ in (5′) generates estimates of the allocative efficiency index $AE(\cdot)$ in (6).

References

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Varian H (1984) The nonparametric approach to production analysis. *Econometrica* **54**, 579–97.

Appendix B. Tables

Table A1. First-step estimation in the control function approach

	Remittance	Land lease-in	Land rent-out
Intercept	3.334***	0.806***	-0.053*
county1	-1.454*	-0.335**	-0.002
county2	-0.629	-0.221	0.113***
county3	1.236*	-0.009	0.016
county4	0.495	0.106	0.055***
county5	0.431	-0.142	-0.001
county6	-1.404**	0.470***	0.043*
county7	-1.060	0.328**	0.042*
county8	-1.836	-0.046	0.018
Age of hh head	-0.025*	-0.011***	0.001***
Dist_c	-0.109	0.348	0.004
Dist_b	0.268	0.305	-0.029
F-value	2.398	5.209	3.798
P-value	0.002	0.001	0.001

Note: The stars indicate the level of significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A2. Factors affecting efficiency – robustness check

Efficiency	**Technical efficiency (TE)**		**Allocative efficiency (AE)**	
	Nonlinear least square	Median regression	Nonlinear least square	Median regression
Intercept	2.724***	1.071	0.475**	0.178
Head_edu1	0.005	-0.038	-0.019	-0.065*
Head_edu2	0.230	-0.031	-0.107	-0.115**
Female head	0.503	0.177	0.438***	0.329***
Age of hh head	-0.007	0.002	-0.001	0.0003
Hh size	-0.041	-0.011	0.072***	0.056***
Dist_c	0.257	0.217	-0.064	0.035
Dist_b	-0.604	-0.760**	-0.237	-0.340**
Remittance	-0.163*	-0.130*	-0.039	-0.002
Land Lease-in	0.040	0.504	0.873***	0.621***
Land Rent-out	-0.378	0.215	1.214	0.501
$\hat{e}$-remit	0.199**	0.138*	0.072**	0.025
$\hat{e}$-lease	0.154	-0.498	-0.922***	-0.648***
$\hat{e}$-rentout	1.308	-0.145	-0.031	0.028

Notes: The nonlinear-least-squares model is based on the specification $mean(E) = 1 - \exp(-Z\,\gamma)$, where $mean(E)$ is the expected value of the efficiency index E, $Z = (Z_1, Z_2, \ldots)$ are the explanatory variables and $\gamma = (\gamma_1, \gamma_1, \ldots)'$ is the vector of corresponding parameters. The stars indicate the level of significance: *** p < 0.01, ** p < 0.05, * p < 0.1.