ANALYSIS OF TECHNICAL EFFICIENCY OF INTENSIVE WHITE-LEG SHRIMP FARMING IN NINH THUAN, VIETNAM: AN APPLICATION OF THE DOUBLE-BOOTSTRAP DATA ENVELOPMENT ANALYSIS

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1. Introduction

- Ninh Thuan province has an area of about 10 km^2 and favorable condition for shrimp farming that contribute 15% GDP of the area.
- In spite of its success, it **faces** some challenges; limited area, low harvest, **lack of technical knowledge,** disease and pollution.
- As researchers, we worked for the best method to improve the technical efficiency of the area.
- Therefore, we undertake this study to improve understanding of the inter-farm differences which will give opportunities to owners and policy makers.

2. Research objectives

(1) Determination of TE of white-leg shrimp farming.

(2) Analysis of factors affecting TE of white-leg shrimp farming.

(3) Policy suggestions to improve EE of white-leg shrimp farms in Ninh Thuan, Vietnam

3. Theory (Previous research)

- The most popular techniques in efficiency measurement are: Data envelopment analysis **(DEA)** and Stochastic frontier analysis **(SFA);**
- The advantage of deterministic DEA is non-parametric hence not require any parametric assumptions.
- However, it does not have a solid statistical foundation behind it and is sensitive to outliers.
- On the other hand, SFA approach predominates in efficiency studies on aquaculture due to the stochastic nature of aquatic culture.

3. Theory (Previous research) (con't)

- Simar and Wilson (2000) have introduced bootstrapping into the DEA framework to overcome these drawbacks.
- Their method is based on: statistical well-defined models for consistent estimation, corresponding technical efficiencies, confidence intervals for efficiency estimates and consistent inferences for efficiencies' factors.
- This paper extends previous studies by adopting the double bootstrap DEA model in comparison with the deterministic DEA approach to analyze efficiency.

4. Methodology

Step 1. Technical Efficiency measurement

- The input-oriented DEA framework, TE_j, is defined as:

$$TE_j(X,Y) = \min_{\theta_j,\lambda} \theta_j$$

- such that:

$$Y_j \leq Y\lambda;\ \theta_j X_j \geq X\lambda;\ \lambda \geq 0;\ \sum_{j=1}^{102} \lambda_j = 1$$

Using both deterministic and double bootstrap DEA **estimate**s (Simar and Wilson 2007)

4. Methodology (con't)

Step 2. Analysis of factors affecting TE

Truncated regression estimation using the double bootstrap method (Simar and Wilson 2007)

$$\widehat{\delta_j} = \boldsymbol{\beta Z}_j + \varepsilon_j \geq 1 \qquad \text{where } \widehat{\delta_j} = 1/\overline{TE_j}$$

The deterministic two-stage DEA analysis with Tobit regression is also conducted:

$$TE_j = \beta_0 + \boldsymbol{\beta Z_j} + u_j$$

Table 1: Description of variables

Variables	Description	Unit
Production model for DEA framework		
Output (Y)	Total quantity of shrimp produced per ha per year	Kilogram
Input (X)		
Seed (X_1)	Fingerlings stocked in the farm per ha per year	1000ind
Feed (X_2)	Total quantity of feed used per ha per year	Kilogram
Labor (X_3)	Total number of man-hours per ha per year	Hour
Chemicals (X_4)	Total amount of fertilizer/chemical applied per ha per year	Kilogram
Power (X_5)	Total Kw of electricity per ha per year	Kw
Farm specific variables		
Farm size (Z_1)	Total area for shrimp aquaculture of the farm	Hectare
Financial stress (Z_2)	Borrowing for production cost (1 = yes, 0 = otherwise)	Dummy
Culture length (Z_3)	The length of shrimp farming per year	Day
Experience (Z_4)	Years the shrimp farmer/manager spent in shrimp farming	Year
Training (Z_5)	Technical training from extension agents (1 = yes, 0 = otherwise)	Dummy
Education (Z_6)	Level of education of shrimp farmer/manager (1 = college or higher, 0 = otherwise)	Dummy

Study Site

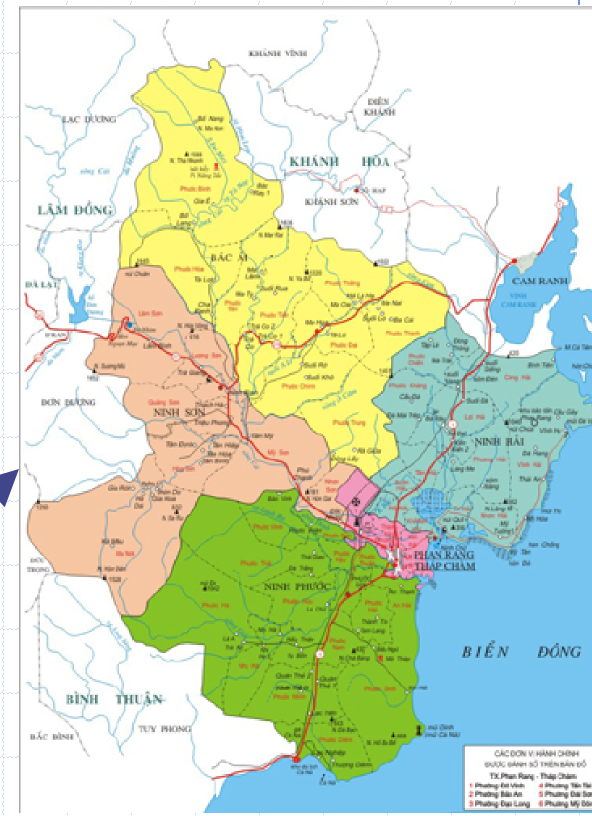

Fig. 1: Ninh Thuan province, Vietnam

5. Results and Discussion

Table 2. Deterministic and double bootstrap DEA estimates.

Description	Deterministic		Double bootstrap	
	TE_CRS	TE_VRS	TE_CRS	TE_VRS
Mean	**0.69**	**0.79**	**0.63**	**0.73**
Median	0.70	0.80	0.63	0.75
Min	0.39	0.40	0.35	0.37
Max	1.00	1.00	0.88	0.91
Upper 95% CI for Mean	-	-	0.67	0.80
Lower 95% CI for Mean	-	-	0.59	0.68

5. Results and Discussion (con't)

Table 3. Mean comparison and correlations of efficiency rankings

Efficiency	Mean		t-ratio	Spearman rank correlation (ρ)	Kruskal-Wallis rank sum test
	Deterministic	Double bootstrap			
TE_CRS	**0.69**	**0.63**	19.028 ***	0.980***	14.748***
TE_VRS	**0.79**	**0.73**	20.022 ***	0.981***	9.615***

***, **, * Significant at 1%, 5% and 10% levels, respectively

5. Results and Discussion (con't)

Table 4 Determinants of technical efficiency score[(a)]: double bootstrap estimation

Variables	Coefficients	Lower 95% CI	Upper 95% CI	Lower 90% CI	Upper 90% CI
Intercept	**0.2923**	-0.8719	1.1264	-0.6147	1.0051
Farm size	**-0.3149****	-0.7216	-0.0521	-0.7098	-0.1053
Financial stress	**0.3538****	0.0292	0.8300	0.0665	0.7075
Culture length	**0.0030****	0.0007	0.0059	0.0010	0.0053
Experience	**0.0174**	-0.0174	0.0539	-0.0111	0.0482
Training	**-0.0757**	-0.3440	0.1969	-0.3062	0.1572
Education	**-0.0089**	-0.3822	0.3375	-0.3183	0.3041

**, * Significant at 1%, 5% and 10% levels, respectively.

(a) Technical efficiency score is the reciprocal of technical efficiency value

5. Results and Discussion (con't)

Table 5: Determinants of technical efficiency score[a]: Tobit regressed estimation

Variables	Coefficient	Standard error	t-value	P-value
Intercept	0.9788**	0.1818	5.384	0.0000
Farm size	-0.1960**	0.0774	-2.530	0.0114
Financial stress	0.1316*	0.0748	1.758	0.0787
Culture length	0.0015**	0.0005	2.778	0.0054
Experience	0.0053	0.0084	0.636	0.5245
Training	-0.0523	0.0662	-0.789	0.4299
Education	0.0348	0.0835	0.417	0.6769

**, * Significant at 1%, 5% and 10% levels, respectively.

(a) Technical efficiency score is the reciprocal of technical efficiency value

6. Conclusion

- There is considerable room for improvement in technical efficiency in the sample of farms analyzed.
- An improvement in technical efficiency among these white-leg shrimp farmers can help to reduce the gap in yield between the most and the least efficient farmers.
- The factors that could **enhance** TE are education, extension training, farming using **earthen** ponds, and the increased size of farms.
- The variables that are negatively related to TE are financial stress, farmer experience and a longer cultivation period.

6. Conclusion (con't)

- The potential improvement in TE (double bootstrap) used in this study is certainly greater than that using deterministic DEA.

- Using a deterministic DEA two step approach, largely remain valid. However, it is advisable to use the Simar and Wilson (2007) double bootstrap procedure on TE in aquaculture studies.

6. Further works

- Determination of AE, CE, EE
- Analysis of factors affecting AE, CE, EE using deterministic approach compared to Double bootstrap DEA approach

Thank you for listening