ANALYSIS OF TECHNICAL, ECONOMIC AND ALLOCATIVE EFFICIENCY OF SAFE VEGETABLE PRODUCTION IN SUBURBAN OF CẦN THƠ CITY

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The result shows that the area for safe vegetable (SV) production in large scale has not developed in Cần Thơ city (CC). In addition, link between SV producers and distributors has not been really well. The SV producers' technical efficiency from the studied area has obtained absolutely (100%). However, due to inappropriate use of factor inputs, the economic and allocative efficiency reached a level of 75%. From the result of analysis documents we conclude that production efficiency is effected greatly by a range of factors such as experience of SV production, number of times being trained in productive technology in year, diversification in farming styles, plot size for production and market information (MI). To develop an SV supply for CC, expansion of market and MI for planters are considered as main solutions.

1. SV production and consumption in Cần Thơ City

From 1993 to 2000, with financial support from FAO, WB, and DANIDA; and fund for agricultural extension, Cần Thơ agricultural authority gave over 1,000 training courses in SV farming techniques to over 35,000 peasants. Formation of areas specializing in SV, however, met with difficulties caused by small-scale production. In 2003, Cần Thơ City Crop Protection Agency worked out a plan to develop SV-specialized zone and give training courses in farming techniques to peasants. At present, there are four zones producing vegetables in Cần Thơ: Hưng Thạnh (Cái Răng District); Trường Long (Phọng Điền); Thới Long and Thới An (Ô Môn); and Thới Thuận (Thốt Nốt). Although initial results of the plan were encouraging, shortage of fund prevented formation of SV-specialized zones (up to 2008).

In 2004, Phong Điền and Bình Thủy Districts and Cần Thơ agricultural authority made plan to develop vegetable zones and expand the SV – specialized zones. Up till now, Districts of Thốt Nốt, Phong Điền, Ô Môn, Bình Thuỷ and Cái Răng have made considerable investments in irrigation systems, given training courses in SV farming techniques, and developed vegetable zones. Particularly, Vegetable Cooperative of Long Tuyền has sold its SV through Metro and Vinatex supermarkets.

Generally speaking, CC failed to develop vegetable zones of large scale and areas. Peasants only produce vegetable at a very small scale. Causes of this situation are numerous: (1) Some vegetable areas, such as Hưng Thạnh (Cái Răng District) and An Bình (Ninh kiều District), have

been zoned for building of residential quarters with the result that peasants couldn't develop the model; (2) Most SV-specialized zones were developed with financial support from authorities and only a few peasants produced SV on their own because the market for SV was small.

The market for SV is a big worry now. Besides some supermarkets that serve customers who are aware of the need for safe vegetables, most marketplaces pay no attention to the SV because there is no proof of safety of vegetables offered for sale. Many traders are of the opinion that SV must be packaged with brands and certificates from authorities. In addition, distribution network for SV is very necessary because only market demand can encourage peasants to produce SV.

2. Advantages and difficulties of production and distribution of SV

a. Advantages:

A survey of 24 peasant families producing the SV shows that they enjoy many favorable conditions for their business: surrounded dykes and good irrigation (18.2% of respondents); free supply of seeds (13.6%), free training (11.4%), experience of vegetable farming (11.4%), and many other advantages, such as no diseases in land newly turned into vegetable gardens, and free supply of organic manure.

As for distribution of vegetables, SV planters can sell their output easily (13.6%), their gardens are near to marketplaces (4.5%), selling prices are stable (4.5%), and they have contracts to sell with purchasers (2.3%).

In addition, many SV planters can grow various kinds of vegetables and sell them to supermarkets in Cần Thơ at higher prices and they start to build brand names for their cooperatives.

b. Difficulties: As for SV planters, capital is the biggest difficulty (18% of respondents). SV planters also face other difficulties: high cost and low quality of inputs (16%); and lack or techniques of growing the SV.

The small scale production is also a problem because it leads to uneven and unstable product quality, shortage of farm hands, and imperfect irrigation system. When selling their output, SV planters suffer unstable prices (16%), purchasers' refusal to buy the agreed-upon quantity (6%), and high transport cost because of long distance or lack of vehicles (6%), along with many others (unstable consumption, lack of market information, falling price after harvest, bad weather, and diseases, etc.)

3. Estimate of business efficiency of SV producers

a. Basic concepts in use:

- Technical efficiency (TE) indicates producer's ability to gain the maximum output from a combination of inputs used for the crop ($0 \le TE \le 1$).

- Allocative efficiency (AE) indicates producer's ability to employ input factors at optimal ratios with current prices and techniques ($0 \le AE \le 1$).

- Economic efficiency (EE) indicates the efficiency based on the two above indicators ($0 \le EE \le 1$) and it is expressed as $EE = TE * AE$.

b. Approach: The main approach in this research is the non-parametric data envelopment analysis (DEA). DEA is a linear programming methodology to measure the efficiency of multiple decision-making units (DMUs) when the production process presents a structure of multiple inputs and outputs. It helps us to gain estimation of production frontiers by employing nonparametric linear models, and results of estimation are points of efficiency for all observations and their values vary from 0 to 1. Objective of the analysis is not to estimate the production function but it is used instead for identifying observed units with the highest efficiency. The analysis allows identification of the best frontiers for all observations used in the analysis. In the DEA literature, an organization is considered as more efficient than others when it uses less input to produce the same amount of output, or make more output with the same input. Calculation of efficiency coefficients is based on the highest ratio of output to input by all observations used for analysis. Data analysis when employing DEA requires two stages: estimating the production efficiency, and then applying regression analysis to measurements of efficiency found in elements relating to institution, policies and socioeconomic conditions that affect the production efficiency.

c. Method of gathering data:

- Secondary data are collected from annual reports by Bureau of Agriculture of districts in surveyed zone and by Cần Thơ Service of Agriculture and Rural Development. The research also uses

results of previous studies of production of and market for the SV.

- First-hand data are based on information gathered during visits to, and examinations of, areas producing SV in HCMC, Tiền Giang, Hậu Giang and Vĩnh Long. The research also employs information from interviews with 24 peasants producing the SV in the surveyed zone with the following sampling method:

+ Taking the list of peasants who took training courses given by the Cần Thơ Service of Agriculture and Rural Development (the list is supplied by CC Crop Protection Agency and Agricultural Extension Agency). The list shows that some 35,000 peasants took the training courses.

+ Cooperating with district and commune officials to find peasants who have taken training courses and kept on producing the SV up to the time of survey. And only 50 peasants are found.

+ Selecting 24 out of the 50 peasants because they specialize in production of vegetable; their vegetable areas are equal to or greater than 500 square meters; and they have produced the SV for at least three years.

d. Model used in the analysis: The DEA model is used for building the production frontiers and working out EE and TE. The AE is then worked out based on the ratio of economic efficiency to TE. The model is based on m input and s output by n peasants. As for the peasant i, data of output and input are reflected in corresponding vectors y_i và x_i. Matrix of input (m x n), X, and matrix of output (s x n), Y, comprise all data from all peasants surveyed.

According to Coelli *et al.* (2002), the DEA model used for calculating the TE is:

$$\text{Min } \theta \qquad (1)$$
$$\lambda,\theta$$
$$\text{Compulsory conditions} - y_i + Y\lambda \geq 0$$
$$\theta x_i - X\lambda \geq 0$$
$$\lambda \geq 0$$

where θ is a scalar quantity, and λ is a vector n x 1 constant. Value of θ obtained from the model 1 is the TE of the peasant i. θ is always smaller than or equal to 1, and the value 1 indicates the point on the production frontier, and thus, the survey peasant obtains the best technical efficiency, according to definition by Farrell, 1957.

Suppose that prices of factor inputs are known, the economic efficiency can be simply worked out by the following DEA model:

$$\text{Min } \theta_{EE} \qquad (2)$$
$$\lambda,\theta_{EE}$$
$$\text{Compulsory conditions} - y_i + Y\lambda \geq 0$$
$$\theta_{EE}\, c_i - C\lambda \geq 0$$
$$\lambda \geq 0$$

where c_i is a scalar quantity expressing costs and C is matrix 1 x n of costs by the peasant i.

In this research, measurements of efficiency coefficient are based on costs, and techniques can be hardly affected by variable return to scale because all surveyed peasants do their business at a small scale. Therefore, efficiency coefficients are calculated with constant return to scale. And the formula of AE is as follows:

$$AE = EE/TE \qquad (3)$$

4. Results and discussion

The surveyed zone produces various kinds of vegetables and employs various kinds of inputs for the same farming area. Variables of output used for estimating coefficients of TE and economic efficiency are total output (tonne), including output of watermelon (y_1), cucumber (y_2), pumpkin (y_3), water spinach (y_4), cabbage (y_5), Mexican mint (y_6), Indian mustard (y_7), winged yam (y_8), bittermelon (y_9), string bean (y_{10}) and spinach (y_{11}). Input variables used in the model comprise: farming area in hectare (x_1), expense on seed, in VND1,000 (x_2), expense on fertilizer, in VND1,000 (x_3), expense on farm drug, in VND1,000 (x_4), hired labor cost in terms of working day (x_5), interest in VND1,000 (x_6), land rental in VND1,000 (x_7), expense on plowing in VND1,000 (x_8), expense on fuel, in VND1,000 (x_9), amortization, in VND1,000 (x_{10}), family labor, in working day (x_{11}).

Coefficients of economic and technical efficiency are estimated using models DEA (1) and (2) and DEAP program. And AE is ratio of EE to TE. These coefficients are shown in Table 1.

Numerical data in Table 1 show that TE coefficient from models DEA varies from 99% to 100% and the average is 100%. The average AE of the surveyed samples is 75.4% with the highest level of 100% and the lowest of 19%. Thus, the average economic efficiency of surveyed peasants is 75.4% (the lowest level if 19% and the highest one is 100%). This indicates existence of economic and

allocative inefficiency of the production in the surveyed zone. However, small coefficients of EE and AE show that the output can be higher, with existing techniques, without more investment in inputs. The EE (75.4%) shows that when the surveyed peasants gain the total efficiency, they can save 24.6% of production cost without reducing the output. In addition, the analysis also shows that the EE gained by peasants varies from 91% to 100% (47%).

According to definition, a low AE is related to deviations from the ratio of input to minimum cost. This means that the peasants have no ability to employ correctly the combination of input and offered prices. In other words, they can't calculate the balance between marginal product of a factors and market price of the said factor. Results of estimates of EE show that the low EE of SV producers in surveyed zone is due to a low AE.

5. Identifying factors affecting the efficiency of SV production

a. Regression model used for analysis:

To explain differences in the efficiency by peasant families, regression of factors relating to peasants' production on efficiency coefficients identified in the DEA model is performed by using the Tobit model. These factors are: access to business information (z_1) (this is a dummy variable whose value is 1 when the producer get regular access to business information and equal to 0 if she/he doesn't); age of the main laborers who directly produce the SV (z_2), years of experience of SV production (z_3), size of peasant's family – number of members who live and work with the peasant (z_4), annual family expenditure, in VND1,000 (z_5), access to local banking institutions for loan – this is also a dummy variable that is equal to 1 when the access is available and 0 when it is not (z_6), peasant's capital used for the SV production, in VND1,000 (z_7), farming area, in hectare (z_8), diversification of production in terms of kinds of vegetables produced annually from the farming area (z_9), and number of technical training courses taken in a year (z_{10}). Dependent variables of the Tobit model are EE, TE and AE coefficients. Thus, the Tobit model (4) is as follows:

$$E_i = E^* = \beta_0 + \beta_1 z_{i1} + \beta_2 z_{i2} + \ldots\ldots + \beta_{10} z_{i10} + v_i \quad (4)$$

$E_i = 1$ when $E^* \geq 1$

$E_i = E^*$ when $E^* < 1$

where i refers to the peasant family i; z_j comprises variables affecting the production efficiency; β_j comprises estimated regression parameters; vi is error; E_i is production efficiency by the peasant i; E^* is latent variable when $E[E^*/x_i] = x_i\beta$. The Tobit model will be regressed using the Stata software.

b. Factors affecting the economic efficiency:

Analysis of Tobit regression function is performed to explain differences in the EE between SV producers in the surveyed samples. Regression results and estimates of marginal efficiency are shown in Table 1.

Regression results in Table 1 show that the years of experience of SV production affect positively and significantly (at significance of 1%) the EE by SV peasant families. This is appropriate to realities because experienced families can absorb and apply advanced techniques more effectively. In addition, they usually use factor inputs more reasonably and thereby gaining higher AE. Results shown in Table 2 also show that one extra year of experience may increase the EE by 9%.

Table 1: Factor affecting the EE of SV producers

Variable	Regression parameter	Standard error	Probability value
Constant	-.2129***	.1026	0.057
Business information (Z_1)	.0545	.0323	0.114
Age (Z_2)	-0.001	.0016	0.526
Year of experience (Z_3)	.0902*	.0284	0.007
Size of family (Z_4)	.0024	.0135	0.861
Family expenditure (Z_5)	.0021	.0013	0.114
Loan from banking institution (Z_6)	.0067	.0149	0.660
Producer's capital (Z_7)	-.0023	.0016	0.183
Farming area (Z_8)	.0775*	.0176	0.001
Diversification of output (Z_9)	.0185***	.0070	0.019
Number of training courses taken (Z_{10})	.0531*	.0106	0.000

* significant at 1%; ** significant at 10%, *** significant at 5%

Source: Field survey in 2008

Data in Table 1 proves that the farming area

affects significantly the EE of SV peasant families with a significance level of 1%. Results of regression analysis show that one more hectare added to the farming area can make the EE increase by 7.75%. This result is appropriate to theory of economies of scale – bigger farming area allow producers to save labor cost on a unit of area, amortization for tools and machines, and expense on plowing; and to apply advanced techniques more effectively in comparison with families with smaller areas.

When asked, peasants in the surveyed zone said that they could increase the farming areas or lease more farming land to produce the SV, but they didn't do so because market for the SV was not stable. Moreover, interviews with local officials and technicians revealed that SV producers could gain high EE for small areas of safe vegetables by cooperating with one another to apply strictly techniques of producing the SV. Generally, relation between farming areas and the EE is controversy because producers paid much attention to the market demand while authorities and agricultural technicians insisted on organization and technical process of SV production.

Regression results in Table 1 show that diversification of vegetables on the same area every year also leads to higher EE. Regression analysis proves that when one more kind of vegetable is grown on the surveyed area, the EE increases by 1.85% at a significance level of 5%. Realities show that the diversification of crop helps producers avoid market risks and enhance the TE because they can avoid diseases caused by long monoculture. In addition, the diversification helps producers make the best use of their land, which enhances the AE.

Results of the analysis show that the number of training courses taken by peasants also affects the EE: when the producer takes one more training course every year, the EE can increase by 5.31% at a significance level of 1%. This fact is apparent because skills of producers are much improved when they get useful knowledge of new techniques, strains, or market information from scientists and technicians. After many discussions with peasants, agricultural technicians and local officials, we saw that transfer of technical knowledge was not linked with introduction and implementation of new models of production with the result that after the training courses, peasants had no incentive to apply their newly obtained knowledge. This fact explains why the SV area in Cần Thơ increased very slowly. Our surveys of SV production in HCMC, Tiền Giang, Vĩnh Long and Hậu Giang show that development of the SV production in these provinces was encouraging because long-term projects were carried out properly by peasants while authorities played well their role in expanding the market for safe vegetables. As mentioned above, the main reason for low EE by SV producers is poor allocation of resources, therefore it's necessary to identify factors affecting the AE in order to work out suggestions about policies and measures to develop the SV production in the surveyed zone.

e. Factors affecting the AE:

Analysis of the Tobit regression equation is used for identifying factors affecting significantly the AE. Dependent variables are AE coefficients

gathered from the DEA (1) and (2), independent variables are similar to the ones used in the Tobit regression equation presented above. Results of the analysis are shown in Table 2.

As shown in Table 2, there are five factors that affect positively and significantly the AE. They are: year of experience, farming area, training courses taken, diversification of output, and regular access to market information. Of these factors, the first three affect positively the AE at a significance level of 1%, and the other two at levels of 5% and 10%. Results of the regression analysis show that one more year of experience can help the producer increase the AE by 8.83%; one more hectare added to the SV farming area can increase the AE by 7.58%; one more training course in a year can make the AE increase by 5.41%; regular access to the market information allows them to improve the AE by 5.8%; and finally, one more kind of vegetable is grown, the producer can increase the AE by 1.82%.

Table 2: Factor affecting the AE

Variable	Regression parameter	Standard error	Probability value
Constant	-0,2092	0,0016	
Business information (Z_1)	0,058**	0,0328	0,100
Age (Z_2)	-0,0009	0,0016	0,563
Year of experience (Z_3)	0,0883*	0,0279	0,007
Size of family (Z_4)	0,0007	0,0135	0,956
Family expenditure (Z_5)	0,0021	0,0013	0,118
Loan from banking institution (Z_6)	0,0057	0,0148	0,709
Producer's capital (Z_7)	-0,0025	0,0016	0,147
Farming area (Z_8)	0,0758*	0,0173	0,001
Diversification of output (Z_9)	0,0182***	0,0070	0,020
Number of training courses taken (Z_{10})	0,0541*	0,0105	0,000

* significant at 1%; ** significant at 10%, *** significant at 5%

Source: Field survey in 2008

6. Conclusion and suggestions

a. Conclusion:

- On production of SV:

+ At present, there is no SV-specialized zone in Cần Thơ.

+ SV is produced at a small scale, which limits relations between producers and distributors.

+ Groups of SV peasants or their cooperatives lack managerial skills of organizing the SV production at a larger scale.

+ Shortage of capital is a great difficulty for SV producers.

+ Unstable prices of SV discourage SV peasants from maintaining and expanding the SV farming areas.

+ Good irrigation systems and support from authorities are two favorable conditions for SV producers. In addition, the increasing market demand for the SV is considered as the most favorable condition.

- On production efficiency and influential factors:

+ Most SV producers gain the absolute TE (100%) but their AE is limited, which makes their efficiency coefficient fall to 75%.

+ Factors that affect positively and significantly the EE are: (1) year of experience (significant at 1%); (2) the farming area is significant at 1%; (3) number of training courses taken in a year is significant at 1%; and (4) diversification of output is significant at 5%.

+ Factors that affect the AE are similar to the ones affecting the EE, and the access to business information, as an extra factor, is significant at 5%.

b. Suggestions:

- Local authorities had better help SV peasants get access to formal sources of finance in order to deal with the shortage of capital needed for maintaining and expanding their business.

- Beefing up or organizing cooperatives of SV production and distribution is necessary. Cần Thơ Trade Promotion Center and Service of Agriculture and Rural Development should help SV cooperatives establish relations with distributors or

wholesalers.

- Cần Thơ Agricultural Extension Center and Cần Thơ University had better keep on giving training courses to SV peasants, especially the ones in effective use of inputs, and help them rationalize their production and diversify their output.

- SV peasants had better cooperate with one another to expand the SV area, apply rotation of crops, diversify the output and ensure supply of SV in large quantity to distributors.

- Cần Thơ Services of Agriculture and Rural Development and of Science and Technology, along with Trade Promotion Center should supply market information regularly to SV cooperatives and peasants■

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