CHAPTER 4

METHODOLOGY

This chapter covers the materials and research methods applied in the study, including data, economic performance criteria, the logical framework of the study, and the concepts of technical and allocative efficiency.

4.1 Data of the study

The primary data, the cross sectional data for the second crop of 2002, were obtained by interviewing farmers in the communes of Phu Vang district. The survey was conducted at 9 of the 13 communes relating to shrimp aquaculture of the district (Phu My, Phu Xuan, Phu Da, Phu Dien, Phu Thuan, Phu Hai, Vinh Thanh, Vinh An and Vinh Xuan). The 9 communes were selected since they have high percentage of shrimp farms as compared to others. Furthermore, both semi-intensive and intensive shrimp aquacultural systems exist in parallel in the communes. Since there were a lot of semi-intensive shrimp aquacultural farms, they were randomly selected. On the contrary, it was found that there were not many intensive shrimp aquacultural farms. Thus these farms were selected on the advice of the Head of the District Department of Agriculture and Statistics. However, since there was no official definition of the shrimp aquacultural systems, it was necessary to interview the farmers in order to categorize the farms as belonging to either SSAS or ISAS. Finally, the selected sample size was 118 observations, comprising 68 and 50 observations from the semi-intensive and intensive shrimp aquacultural systems, respectively.

Secondary data were collected from the Department of Agriculture, Fishery and Statistics of the Phu Vang district, from the Department of Fishery of Thua Thien Hue province, and from the other official information resources.

4.2 Economic performance criteria

As reviewed in Chapter 3, there are a lot of system performance criteria; however, when applied to a specific system, only a few of these criteria might be thought relevant by the farm family or other decision makers. The two shrimp aquacultural systems chosen in the study could, for example, have a profit objective and would therefore be evaluated in terms of profit. In addition, the purpose of the study is to compare the economic performance of the shrimp aquacultural systems, thus the following performance criteria have been selected: profitability, productivity, technical efficiency and allocative efficiency.

The selection of the above performance criteria does not mean that other performances are not important. For instance, complementarity and environmental compatibility performance is extremely important in every corner of the world today. Nevertheless, this performance is beyond the scale of an individual study, hence it was not selected. Time dispersion performance would help evaluate the system performance better than and more fully; however, farmers in the research site do not keep farm records, so it is hard to obtain data from previous crops or previous years. Furthermore, farmers cannot remember the exact details of the inputs used, or of the profitability and productivity performance gained of previous crops. That is why only one crop data (the second crop of 2002) was collected and used for the study and time dispersion performance could not be analyzed and compared.

The profitability, productivity, TE and AE performances are considered as follows.

4.2.1 Profitability performance

Profitability performance can be evaluated by criteria such as total gross return (TGR), net return (NR), and gross margin (GM).

Total gross return (TGR). It is the sum of all outputs (Q) times their prices (P). The formula is TGR = Q*P.

Net return (NR). It is obtained as NR = TGR – TC. Where TC is total cost. TC consists of two components, total variable cost (TVC) and total fixed cost (TFC). TC = TVC + TFC.

Gross margin (GM). GM is obtained as total gross returns less variable costs, GM = TGR – VC, i.e., fixed costs are ignored since, by their nature, they have to be met whatever is produced (and even if nothing is produced) (McConnell and Dillon, 1997).

In this study TVC and TFC are calculated as follows.

TVC = Seed costs + Feed costs + Disease prevention costs + Pond preparation costs + Tool costs + Maintenance costs + Fuel costs + Interest + Harvest costs + Labor costs

TFC = Pond depreciation costs + Machine depreciation costs

The cost items in TVC and TFC are defined as follows:

Seed costs. These are expenditures related to buying seed: price of seed, transportation cost, cost for hatchery sample test and others.

Feed costs. These are the costs of both processed feed and fresh feed (henceforth referred to as feed). Processed feed is produced by processing companies while fresh feed (egg yolks, meat, fish, etc.) is produced by farms.

Disease prevention costs. These are the total costs of materials used for preventing and curing shrimp disease.

Pond depreciation cost. Pond depreciation is calculated by total investment in ponds at the beginning of shrimp aquaculture with the ten-year (fifteen-crop) duration using the straight-line depreciation method. The 10-year or 15-crop duration has been selected as the depreciation time, based on the duration that shrimp ponds are sold to shrimp farms by the Commune People's Committee (Chapter 5); and on average 1.5 crops are cultured per year.

Pond preparation costs. These include costs of bottom pond clearing, water preparation and plankton culture for each crop. These activities will be elaborated in Chapter 5.

Machine depreciation costs. These are calculated from total investment in water pumps and aerators using the straight-line depreciation method. The majority of surveyed farmers (83.7%) reported that after about 6 crops of usage, machines might not be used any more, therefore 6 crops or 4 years has been selected as the depreciation time (average of 1.5 crops is cultured per year).

Tool costs. These consist of expenditures on feeding trays, vessels, etc. used for shrimp feeding.

Maintenance costs. These are expenditures on buying spare parts and repairing machines.

Fuel costs. These are total expenditure on fuel and lubricant used for water pumps and aerators.

Interest. This is total money paid for loans from the banks or loaners. Since on average a shrimp cultural crop lasts for 4 months, this duration and the relevant interest rate of each farm are used to calculate the interest.

Harvest costs. These costs consist of expenditures on labors and machines hired to harvest shrimp.

Labor costs. Labor cost consists of total wage paid for taking care and feeding shrimp, not including the labor cost of pond building, pond treatment, or harvesting shrimp.

4.2.2 Productivity performance

In analyzing productivity performance the following criteria have been considered:

(1) Shrimp yield: This performance is calculated by kg of shrimp harvested per unit area (kg/sao).

(2) FCR (feed conversion ratio): Comparison of the amount of feed supplied and the growth of the shrimp allows the food conversion ratio. The FCR is a measure of the weight of shrimp produced per kg of feed supplied (Chanratchakool *et al*., 1998). FCR = (Total feed/ Final biomass).

(3) Total factor productivity: Total factor productivity is total output divided by total input. As in the case of individual resource productivities, the problem of outputs and of inputs each being of diverse physical forms is met by aggregating each to their respective total on the basis of the common unit of money value based on market price for outputs and market or opportunity cost for inputs. McConnell and Dillon (1997) suggested gross total factor productivity (GTFP) and net total factor productivity (NTFP) as the two measurements of total factor productivity.

Gross total factor productivity (GTFP) = Total gross returns/Total costs

Net total factor productivity (NTFP) = Total net returns/Total costs

(4) Net returns on main inputs used:

Net returns on post larva (NR/PL) = (TGR – every cost except seed costs)/Total post larva

Net returns on feed (NR/Feed) = (TGR – every cost except feed costs)/Total kg of feed

Net returns on labor (NR/Labor) = (TGR – every cost except labor costs)/Total labors

Net returns on fuel (NR/Fuel) = (TGR – every cost except fuel costs)/Total litres of fuel.

4.2.3 Technical efficiency (TE)

Technical efficiency refers to the ability to minimize input used in the production of a given output vector, or the ability to obtain maximum output from a given input vector. A technically efficient firm produces the maximum possible output from the inputs used, given locational and environmental constraints, and it minimizes resource inputs for any given level of output. Measurement of efficiency of economic activity is an attempt to assess the performance of an industry or an individual firm in using real resources to produce goods and services. Technical efficiency is a purely physical notion that can be measured without recourse to price information and without having to impose a behavioral objective on producers, cost, and revenue (Kumbhakar and Lovell, 2000).

To increase TE, either output must be increased relative to inputs, or inputs must be relatively decreased. TE can be accessed both statically, with reference to existing technology, and dramatically, through predicting the effects on input/output ratios of technological, managerial or other innovations. In order to access and potentially increase the TE with which firms operate, inputs used and outputs produced must be identified and measured. It is unlikely that optimal relations between inputs and outputs will be specified, but relative levels of TE, or TI, can be measured by comparing differences between similar firms' levels of inputs and outputs. This will also help identify ways of improving TE (Scarborough and Kydd, 1992).

4.2.4 Allocative efficiency (AE)

Allocative efficiency is defined as the ability of firms to obtain the maximum profit from the application of conventional inputs with a given set of firm specific input and output prices and a given technology.

4.3 Logical framework of the study

The following is the logical framework of the study (Figure 4.1). It depicts the selected economic performance criteria and the research methods corresponding to economic performance. The research boundary borders the economic performance criteria and the research methods.

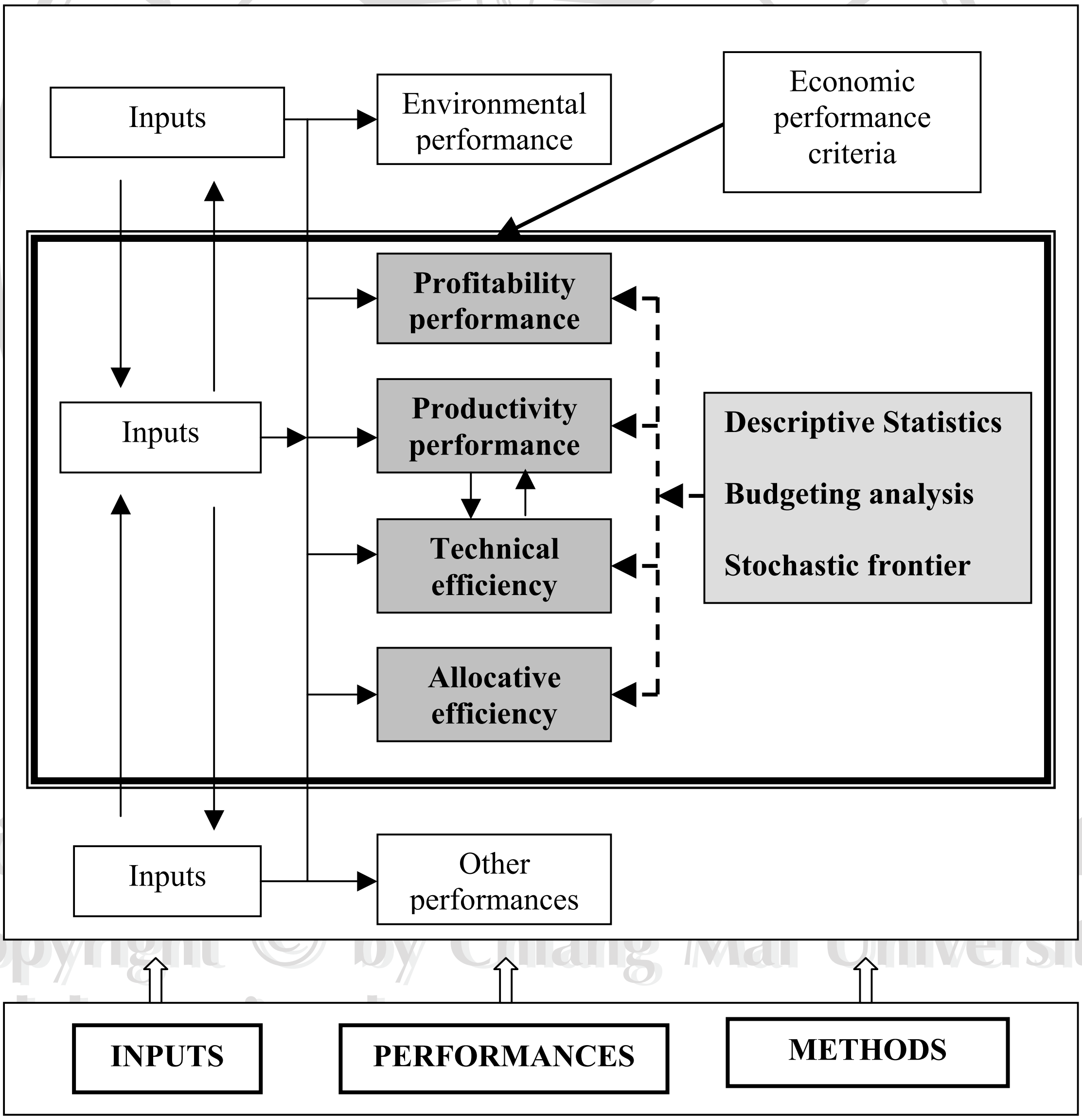


Figure 4.1 Logical framework of the study

Note: The meanings of the arrows used in the figure are as follows:

→ : the relationship or interaction.

- - -▶ : research method used for corresponding performance.

═ : the research boundary.

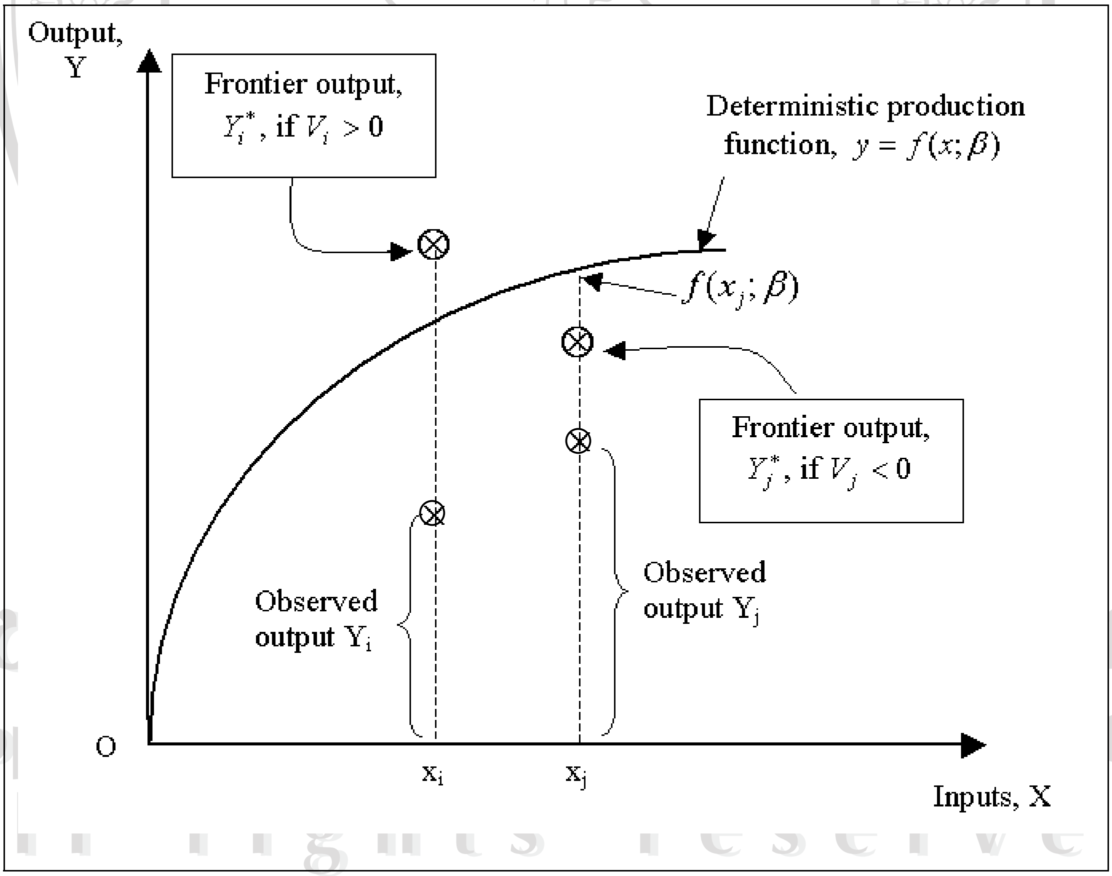
4.4. Stochastic frontiers

The stochastic frontier is defined by

$$Y_i = f(x_i;\beta)\exp(V_i - U_i) \qquad i = 1,2,...,N \qquad (4.1)$$

This stochastic frontier model was independently proposed by Aigner, Lovell and Schmidt (1977) and Meeusen and Van den Broeck (1977). Where V_i is a random error having zero mean, which is associated with random factors (e.g., measurement errors in production, weather, industrial action, etc.) not under the control of the firm. The model is such that the possible production, Y_i, is bounded above by the stochastic quantity, $f(x_i;\beta)\exp(V_i)$; hence the term *stochastic frontier*. The random error, V_i, $i = 1,2,...,N$, were assumed to be independently and identically distributed as $N(0,\sigma_V^2)$ random variables, independent of the $U_i^{'}$s, which were assumed to be non-negative truncations of the $N(0,\sigma^2)$ distribution (i.e., half-normal distribution) or have exponential distribution. Meeusen and Van den Broeck (1977) considered only the case in which the $U_i^{'}$s had the exponential distribution (i.e., gamma distribution with parameters $r = n$ and $\lambda = 1$) considered by Richmond (1974) (Battese, 1992).

The basic structure of the stochastic frontier model (1) is depicted in Figure 5.2 in which the productive activities of two firms, represented by i and j, are considered. Firm i uses inputs with values given by (the vector) x_i and obtains the output, Y_i, but the frontier output, Y_i^*, exceeds the value on the deterministic production function, $f(x_i;\beta)$, because its productive activity is associated with "favorable" conditions for which the random error, V_i, is positive. However, firm j uses inputs with values given by (the vector) x_j and obtain the output, Y_j, which has corresponding frontier output, Y_j^*, which is less than the value on the deterministic production frontier, $f(x_j;\beta)$, because its productive activity is associated with "unfavorable" conditions for which the random error, V_j, is negative. In both cases the observed production values are less than the corresponding frontier values, but the (unobservable) frontier production values would lie around the deterministic production function associated with the firms involved (Battese, 1992).



Source: Battese, 1992

Figure 4.2 Stochastic production frontier

The TE of an individual firm is defined in terms of the ratio of the observed output to the corresponding frontier output, conditional on the levels of inputs used by that firm. Thus the TE of firm i in the context of the stochastic frontier production function (1), namely TE_i, is

$$TE_i = Y_i \big/ Y_i^*$$

$$= f(x_i;\beta)\exp(V_i - U_i) / f(x_i;\beta)\exp(V_i) = \exp(-U_i)$$

4.4.1 Theoretical models of production frontiers

If the production frontiers for the semi-intensive and intensive shrimp aquacultural systems are specified respectively as:

$$y_{1i} = X_{1i}^{'} + \varepsilon_{1i} \tag{4.2}$$

$$y_{2i} = X_{2i}^{'} + \varepsilon_{2i} \tag{4.3}$$

Where y_{1i} = semi-intensive shrimp output, y_{2i} = intensive shrimp output, X_{1i} = a $k_1 \times 1$ vector of inputs for semi-intensive shrimp, X_{2i} = a $k_2 \times 1$ vector of inputs for intensive shrimp, β_1 = a $k_1 \times 1$ vector of parameters associated with X_{1i}, β_2 = a $k_1 \times 1$ vector of parameters associated with X_{2i}, ε_{1i} and ε_{2i} = error terms for semi-intensive and intensive shrimp productions, i = the ith observation. The respective production frontiers may be written as

$$y_{1i} = X_{1i}^{'}\beta_{'1} + v_{1i} - u_{1i} \tag{4.4}$$

$$y_{2i} = X_{2i}^{'}\beta_{'2} + v_{2i} - u_{2i} \tag{4.5}$$

Where $v_{1i} \sim N(0,\sigma_{v_1}^2)$, $v_{2i} \sim N(0,\sigma_{v_2}^2)$; u is truncated normal and

$$f(u) = \frac{2}{\sigma_u (2\pi)^{\frac{1}{2}}} \exp\left[\frac{-u^2}{2\sigma_u^2}\right] \; ; \; (u \geq 0) \tag{4.6}$$

The term – u is the one-sided error. This implies that each observation is on or below the frontier. –u is called "technical inefficiency" (Maddala, 1983). The u_{1i} and u_{2i} are non-negative random variables and called technical inefficiency effects, which are assumed to be independently distributed such that u_{1i} and u_{2i} are defined by the truncation (at zero) of the normal distribution with mean μ_{1i} and μ_{2i} and variances $\sigma_{u_1}^2$ and $\sigma_{u_2}^2$ (Seyoum *et al.*, 1998). v is the usual two-sided error that represents the random shifts in the frontier due to favorable and unfavorable factors. It captures measurement error in y as well.

If u and v are distributed independently, from Weistein's result (1964), we obtain:

$$g(\varepsilon_1) = \frac{2}{\sigma} \phi\left(\frac{\varepsilon_1}{\sigma_{\varepsilon_1}}\right)\left[1 - \Phi\left(\frac{\varepsilon_1 \lambda_1}{\sigma_{\varepsilon_1}}\right)\right] \tag{4.7}$$

$$g(\varepsilon_2) = \frac{2}{\sigma} \phi\left(\frac{\varepsilon_2}{\sigma_{\varepsilon_2}}\right)\left[1 - \Phi\left(\frac{\varepsilon_2 \lambda_2}{\sigma_{\varepsilon_2}}\right)\right] \tag{4.8}$$

Where $\sigma_{\varepsilon_1}^2 = \sigma_{v_1}^2 + \sigma_{u_1}^2 \; ; \; \lambda_1 = \sigma_{u_1} / \sigma_{v_1}$

$\sigma_{\varepsilon_2}^2 = \sigma_{v_2}^2 + \sigma_{u_2}^2 \; ; \; \lambda_2 = \sigma_{u_2} / \sigma_{v_2}$

$\phi(.)$ and $\Phi(.)$ = density function and distribution function of standard normal distribution respectively.

The estimation method for production frontiers was suggested by Aigner *et al.* (1977). To measure average inefficiency, Aigner, Lovell, and Schmidt (1977) suggested using $\lambda = \sigma_u / \sigma_v$ and $E(-u) = \left[2^{\frac{1}{2}} \Big/ \pi^{\frac{1}{2}} \right]$. In the case of Cobb-Douglas, the production frontier may be expressed as

$$y = AK^{\alpha} L^{\beta} e^{-u} e^{v} \tag{4.9}$$

In this case technical efficiency is

$$e^{-u} = \frac{y}{AK^{\alpha} L^{\beta} e^{v}} \tag{4.10}$$

–u is half normal. The mean of TE is, then, obtained as

$$E\left(e^{-u}\right) = 2\exp\left(\frac{\sigma_u^2}{2}\right)\left[1 - \phi(\sigma_u)\right] \tag{4.11}$$

(Maddala, 1983)

Jondrow *et al.* (1982) showed the method of estimation of individual farm inefficiency by showing that the expected value of u for each observation could be obtained from conditional distribution of u, given ε, and with the normal distribution for v and half normal for u. the expected value of inefficiency for each farm, given ε, can be obtained as

$$E(u/\varepsilon) = \frac{\sigma_u \sigma_v}{\sigma_\varepsilon} = \left[\frac{\phi(\varepsilon\lambda/\sigma_\varepsilon)}{1 - \Phi(\varepsilon\lambda/\sigma_\varepsilon)} - \frac{\varepsilon\lambda}{\sigma_\varepsilon} \right] \tag{4.12}$$

(Bravo-Ureta and Rieger, 1991; Wang *et al.*, 1996)

4.4.2 Production frontier estimation with inefficiency equation

u_{1i}'s and u_{2i}'s are non-negative random variables which are assumed to be independently distributed such that u_{1i} and u_{2i} are defined by the truncation (at zero) of normal distributions with mean μ_{1i} and μ_{2i} and variances $\sigma_{u_1}^2$ and $\sigma_{u_2}^2$

respectively. Seyoum *et al*. (1998) defined each μ_i as a function of some explanatory variables:

$$\mu_{1i} = \theta_{11} + \theta_{12} F_{2i} + \ldots + \theta_{1m} F_{mi} \tag{4.13}$$

$$\mu_{2i} = \theta_{21} + \theta_{22} F_{2i} + \ldots + \theta_{2m} F_{mi} \tag{4.14}$$

Where $F_2, \ldots, F_n$ are explanatory variables.

The maximum likelihood estimates for all parameters of the stochastic frontier and inefficiency model, defined by equations (4.4) and (4.13); (4.5) and (4.14) are simultaneously obtained by using the computer program FRONTIER Version 4.1 (Coelli, 1996) which estimates the variance parameters in terms of parameterization.

$$\sigma_{\varepsilon_1}^2 = \sigma_{v_1}^2 + \sigma_{u_1}^2 \tag{4.15}$$

$$\sigma_{\varepsilon_2}^2 = \sigma_{v_2}^2 + \sigma_{u_2}^2 \tag{4.16}$$

And

$$\gamma_1 = \sigma_{u_1}^2 / \sigma_{\varepsilon_1}^2 \tag{4.17}$$

$$\gamma_2 = \sigma_{u_2}^2 / \sigma_{\varepsilon_2}^2 \tag{4.18}$$

(Seyoum *et al*., 1998)

4.5 Allocative efficiency

For a profit maximizer, the optimal level of input used is where marginal value production frontier product (MVP) equals unit input cost (Figure 4.3).

In Figure 4.3, X_i^* is the optimal input level used; since at this point the MVP of input X_i and its price equal each other. Accordingly, profit of the producer is maximized. If input X_i is used beyond X_i^* level (or MVP is smaller than input price), profit will reduce. In contrast, profit will increase when the input X_i is used up to X_i^*.

The usual test for allocative efficiency is to compare the marginal value product of input with the price of input.

$$MVP_{X_i} = P_{X_i} \qquad \text{or} \qquad \frac{MVP_{X_i}}{P_{X_i}} = 1 \tag{4.19}$$

If $\frac{MVP_{X_i}}{P_{X_i}} = 1$, input X_i is used in an allocatively efficient way by the firm.

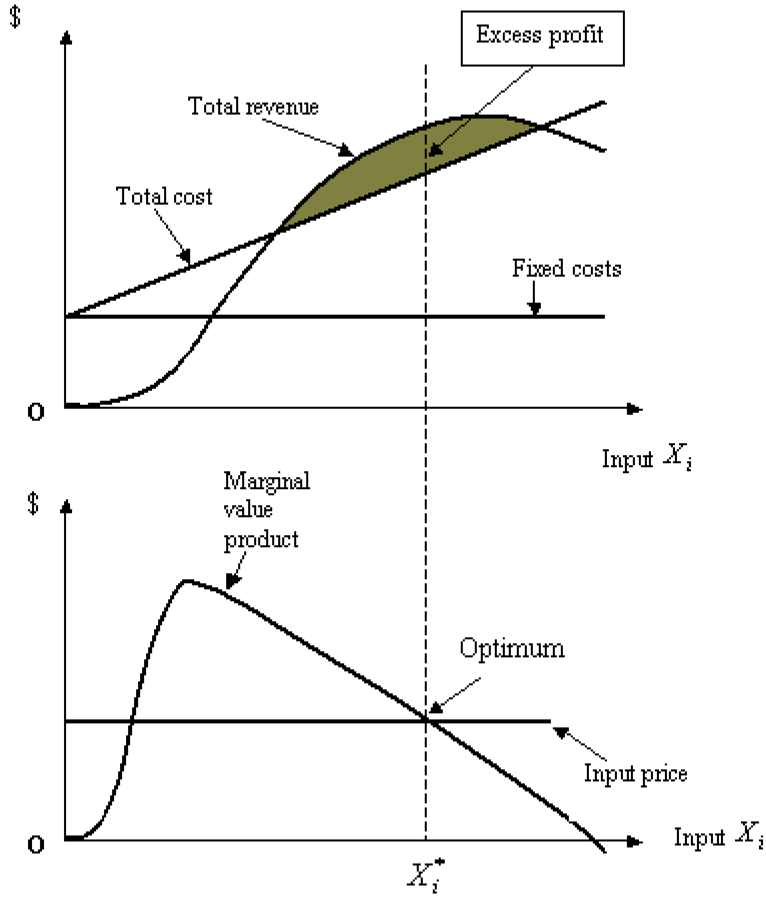


Figure 4.3 Allocative efficiency and profit maximization

Where P_{X_i} is the price of input X_i; MPV_{X_i} is the marginal value product of input X_i and this is the product of multiplication of marginal product of input X_i, MP_{X_i}, and output price, P, as follow:

$$MPV_{X_i} = MP_{X_i} * P \tag{4.20}$$

Moreover, $MP_{X_i} = \omega_i * AP_{X_i}$ (4.21)

Where ω_i is the output elasticity of an input X_i. MP_{X_i} and AP_{X_i} are Marginal Product and Average Product of input X_i, respectively.