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PANEL DATA ANALYSIS ON FARM-LEVEL EFFICIENCY, INPUT DEMAND AND OUTPUT SUPPLY OF RICE FARMING IN WEST JAVA, INDONESIA

By

ERWIDODO

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ABSTRACT

PANEL DATA ANALYSIS ON FARM-LEVEL EFFICIENCY, INPUT DEMAND AND OUTPUT SUPPLY OF RICE FARMING IN WEST JAVA, INDONESIA

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This study has three main objectives: (i) to generate and evaluate parameters of rice production system, especially those related to efficiency, returns to scale, the demand for inputs and the supply of rice, (ii) to identify factor affecting farmers' decisions in the adoption of new rice varieties, and (iii) to evaluate current agricultural policies, particularly price support and input subsidy policies.

This study uses stochastic production and stochastic profit frontier models. Two functional forms (i.e. Cobb-Douglas and translog) are used in the analysis. The models are estimated using panel data from rice farming regions in West Java, Indonesia. Both single equation and system equation estimation methods are used in the analysis. In addition, a multinomial logit model is used to assess farmers' behavior in adopting new rice varieties.

This study confirms that rice production in West Java is in the stage of constant returns to scale. Rice farmers in West Java are found to be allocatively inefficiency and are, on the average, about seven percent technically inefficient and fourteen percent economically (profit) inefficient. Using average figures of profit per hectare and annual harvested area in West Java, the total profit loss amounts to about seventy eight billions or eighty million US dollars annually. The benefits

of promoting increased efficiency in rice farms in Indonesia appear to be considerable. The results also show that individual level of technical and profit inefficiency does not have any association with individual farm size, meaning that large farms may or may not be technically or economically more efficient than small farmers. Provision of reasonable incentives for rice farmers is necessary if the adoption of new rice varieties is an important government's priority.

If increasing rice production and promoting rural employment are the government's primary concern, this study verifies the argument that price support policy is more effective and less costly than fertilizer subsidy policy. Considering government's budget constraints, the implementation of improved price support policy, coupled with a gradual reduction in input subsidies, may be one alternative to maintain the long-run rice self-sufficiency goal. Technological and institutional changes including efforts in improving marketing efficiency are necessary to simultaneously realize both higher producer and lower consumer prices.

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I. INTRODUCTION

1.1. Research Background and Problems Setting.

During the first half of the 1960s, rice production in Indonesia remained static while population grew rapidly, resulting in a significant food shortages and eventually making Indonesia as the world's largest rice importing country. Faced with this situation, the government has implemented numerous policy instruments and programs. The rehabilitation and expansion of the irrigation systems, continued investment in agricultural research capacity, the implementation of nation-wide rice intensification programs, the introduction of high yielding rice varieties, and continued provision of highly subsidized inputs (fertilizers and pesticides) were, among others, the major factors signifying the increase of rice production in Indonesia. All these efforts have resulted in significant benefits during the late of 1960s up to the late of 1970s when the rate of growth of rice was as high as eight percent annually. Since 1985, after struggling more than two decades, Indonesia has become self-sufficient in rice.

Much of the early success, however, did not persist and the rate of growth of rice has been declining. During the period of 1982-1985, for instance, the annual growth rate of rice production declined to five percent, and continuously declining to only 1.3 percent during the period of 1985-1987. Given this declining growth rate of the rice production on the one hand, and a rapid growth of total rice demand (stemming from a steady population growth rate of 2.3 percent and increased private income) on the other hand, critics recently have questioned the ability of the

Indonesian government to maintain rice self-sufficiency in the long run.

Some scientists consistently assert that the strategy for reaching rice self-sufficiency in Indonesia is very costly and can be achieved only at the expense of efficiency. Thes strategy, as applied in most Asian countries, has been characterized by high levels of subsidies on capital infrastructure, production inputs, as well as subsidies for governmental marketing systems, resulting in heavy annual budgetary expenditures by the government. Considering the government's recent budget difficulties, particularly due to the significant reduction of oil revenues, new policies should be directed to find the least costly alternatives. The most recent policy direction in Indonesia is a general movement toward phasing out all type of subsidies.

Besides the macro issues and problems mentioned above, attention should also be directed to the micro level to assess common problems faced by farmers, since farmers are the key factor for successful implementation of any agricultural policy. For example, the optimal application of new technologies and cultivation practices depend, among other things, on the farmer's understanding of these new technologies as well as their capability to adopt them. Better understanding will lead farmers to optimally allocate production inputs, which in turns leads them to achieve maximum profits. Identification of factors affecting the adoption of new rice varieties seems urgently needed, since to date the traditional varieties are still widely grown, despite the high yielding varieties have long been introduced. Measurement of farm level efficiencies along with identification of factors affecting them are also important for policy makers to improve efforts in increasing rice production.

This study aims to examine the above issues, particularly those related to the following policy questions. Do farmers, with their existing constraints and knowledge, behave rationally, i.e. utilize the available resources to produce in economically (technically and allocatively) efficient ways? If most farmers behave inefficiently, how inefficient are they? What factors affect individual farm efficiency. Does the rice yield increasing technology increase farms profit and rural employment? If it indeed increases profitability why are traditional varieties still widely used? What factors determine the adoption of high yielding varieties? Is a tendency for land consolidation in Java theoretically justifiable? Are existing programs, price support and subsidies among others, economically justifiable, especially in terms of increasing productivity, farmer's income and promoting employment in the rural areas? Which one is more desirable, price support or fertilizer subsidy policy, in terms of increasing rice production and rural employment?

1.2. Research Objectives

Using a stochastic frontier model and panel data, this research has the following main objectives:

(a) to generate and evaluate parameters of rice production system, especially those related to farm level efficiency, return to scale, demand for inputs and supply of rice.

(2) to identify factors affecting farmers' decisions in the adoption of new rice varieties.

(3) to evaluate current agricultural policies, particularly price support and input subsidy policies.

Efficiency measures of rice farming are important for the government to improve its efforts to increase rice production in less costly ways. Better information about efficiency is also needed to assess policies in agrarian reform, in general, and in particular on planning and reorganizing rice production system in terms of resource allocation and agricultural extension policies. If farmers, for example, are found to be inefficient, and the level of efficiency is not the same among (groups of) farmers, the government can use this information to set up group-specific extension policies to improve efficiency. A better measure of efficiency provides decision makers information about the potential benefits from promoting improved efficiency.

Another illustration of the potential value of information on farm level efficiency is related to credit policy. Since the late 1970s, for example, the government has subsidized tractor adoption by providing credit at low interest rates to farmers wishing to purchase tractors. In fact, only large farmers benefit from this policy due to their ability to provide collateral to obtain the loan. If the economic efficiency level of large farmers is the same as that of small farmers, providing fair tractor-rental arrangements is probably a more desirable policy, since participation is accessible to both groups of farmers.

Knowledge of returns to scale is very important in assessing the potential economic impact of alternative land reform policy. If, for instance, increasing returns to scale exist, it can be used as a basis for supporting any effort toward land consolidation, or at least not excessively opposing land consolidation, which has spontaneously been occurring in Java.

New rice varieties, commonly referred to as high yielding varieties

(HYV), have long been promoted by the government to accelerate the growth of rice production. In some places, however, the traditional varieties which are usually low yielding varieties, are still used by farmers. Identifying factors which affect the adoption process is urgently needed by the policy makers to formulate policy alternatives to encourage farmers' adoptionof new varieties.

The Indonesian government's price policy to increase rice production consists of (i) subsidizing inputs, and (ii) establishing a floor price for unmilled and milled rice. Some scientists, such as Timmer (1975), argue that using fertilizer subsidies does not provide a strong incentive for farmers to increase production. Some argue that price supports would be more effective than input subsidies in increasing rice production and promoting employment. The estimates of own- and cross-elasticities of factor demand and output supply, which will be obtained in this study, can be used to determine whether to put more emphasis in the implementation of input subsidy or price support policy.

The above issues and questions are not new and some of them have already been evaluated in some previous studies. This study, however, attempts to evaluate the above questions using a different analytical framework. For instance, instead of using non-frontier models in a cross-sectional framework in assessing efficiency (e.g., Sugianto (1982), Kasryno (1986)), this study uses stochastic frontier models in a panel data framework. Unlike Hutabarat (1985) and Gunawan (1988) who applied probit and logit model, respectively, this study applies a multinomial logit model in assessing determinants of the adoption of new rice varieties.

Farm-level panel data used in the analysis are obtained from the Center for Agro-Economic Research, Ministry of Agriculture, Indonesia. Panel data, which are time-series on a set of cross-sectional data, offer several major advantages over conventional cross-sectional or time-series data (described later). To date several studies have used these data (Hutabarat, 1985; Kasryno, 1985; Gunawan, 1988), but these studies did not use the data in the framework of panel data analysis.

1.3. Organization of the Thesis

Chapter 2 presents a brief review of Indonesian agriculture along with the description of the survey and the data set used in this study. In reviewing Indonesian agriculture attention is given to presenting the role of the agricultural sector, the importance of rice, and the past and current agricultural policies. The description of the data set starts by presenting the general description of the study area, the nature of the survey, followed by the description of village characteristics.

Chapter 3, is a literature review of the analytical framework used in this study taking into account the nature of the data, which mainly consists of reviewing panel data analysis, frontier models, dual approach of the production theory, a multinomial logit model, and a literature of price policy evaluation.

Chapter 4 describes the model selection, formulation as well as the parameter estimation procedures. The proposed policy evaluation procedure and data transformation for obtaining the variables included in the model are also discussed in this chapter. Discussion of empirical results is presented in chapter 5, beginning with the results of the descriptive analysis, and followed by production function and production inefficiency, profit function and profit inefficiency, output supply and input demand function and the results of the multinomial logit model.

Finally, chapter 6 presents the conclusions of the study consisting of the summary of the empirical findings, policy implications and recommendations for further research.

II. REVIEW OF INDONESIAN AGRICULTURE AND THE DATA SET

This chapter consists of two sections. Section one briefly reviews Indonesian agriculture, beginning with the role of agricultural sector in the Indonesian economy, the importance of rice and the past and current agricultural policies. Section two describes the data set used in this study, consisting of the description of the survey, the survey area and the sampling procedure and a brief description of characteristic of the sample villages.

2.1. Review of Indonesian Agriculture

2.1.1. Role of the Agricultural Sector

The relative importance of a sector in the economy can be assessed from its contribution to gross domestic product (GDP) and to employment. Through 1985, the agricultural sector has played a dominant role in the Indonesian economy in these two respects. In 1985, the agricultural sector accounted for 23.6% of the GDP, followed by mining and quarrying, public and other services, trade and commerce, and manufacturing industry, which accounted for 16.2%, 15.8%, 15.4%, and 13.2%, respectively. At the same time, the share of the agricultural sector of the total employment amounted to 54.7%, followed by the trade and commerce (14.9%), public and other services (13.4%), and the manufacturing industry (9.3%). The breakdown of sectoral contribution to GDP and employment is presented in table 2.1.

Table 2.1. Sectoral Share (%) to the Gross Domestic Product (GDP) and Employment

Sectors	GDP*		Employment	
	1971	1985	1971	1985
Agriculture	44.9	23.6	66.4	54.7
Farm Food Crops	26.2	14.7	na	na
Farm Non-Food Crops	5.3	3.2	na	na
Estate Crops	2.9	0.6	na	na
Livestock Products	3.4	2.4	na	na
Forestry	3.9	0.1	na	na
Fishing	3.2	1.6	na	na
Mining and Quarrying	8.0	16.2	0.2	0.7
Manufacturing Industry	8.4	13.2	6.8	9.3
Electricity, gas and water	0.5	0.8	0.1	0.1
Construction	3.5	5.3	1.7	1.7
Trade and Commerce	16.1	15.4	10.8	14.9
Transport/Communications	4.4	6.5	2.4	3.1
Banking & Finance	1.2	2.9	0.3	0.4
Public & other services	13.0	15.8	11.2	13.4

Source: CBS. Statistical Year Book of Indonesia
* Based on current price
na = not available

From table 2.1, it is obvious that the relative importance of the agricultural sector in the Indonesian economy, even though still dominant, is gradually declining. This shift suggests a structural change of the economy, the shift from agriculture to others. In 1971, for instance, the agricultural sector accounted for about 45% of the GDP and declined to 24% in 1985. Similarly, its share in employment has declined from about 66% in 1971 to about 54% in 1985. On the other hand, the contribution of mining and quarrying, and manufacturing industry to GDP have increased significantly during this period. Table 2.1 also shows that the trade and commerce and the manufacturing industry are becoming relatively more important in generating employment.

Within the agricultural sector, food crops contributes the highest share to GDP, followed by non-food crops and livestock products (see table 2.1). The farm food crops can be classified into two distinct groups: (i) rice as the country's primary food, and (ii) five other crops (traditionally classified as secondary food crops) consisting of maize, cassava, sweet potatoes, peanuts and soybeans. In terms of area grown (harvested) in the country, rice roughly accounts for more than 60% of the total food crop harvested area.

The farm subsector is dominated by small-scale and traditional farm households. Table 2.2 shows that 45.7% of the farm households in 1973 operated farm sizes which averaged less than 0.5 hectare. This percentage increases to 63.3% in 1980. Number of landless farmers has consistently increased at a higher rate than owned-operated farmers. The landless farmers amounted to 3.2 percent of the total farm households in 1973, and increased to 14.9 percent of the total in 1980.

Table 2.2. Number of Farm Households According to Farm Size and Status

Land Status	1973 Agri-Census Number	1973 Agri-Census Percent	1980 Pop-Census Number	1980 Pop-Census Percent
Less than 0.5 ha:	6,560,758	45.7	11,027,653	63.3
Owned operated	4,907,495	34.2	7,914,305	45.4
Owned and rented	1,356,843	9.4	1,018,048	5.8
Rented	296,420	2.1	2,095,300	12.0
More than 0.5 ha:	7,812,784	54.3	6,440,907	36.9
Owned operated	5,839,027	40.6	4,935,162	28.3
Owned and rented	1,813,831	12.6	999,254	5.7
Rented	159,926	1.1	506,491	2.9
Total	14,373,542	100.0	17,468,560	100.0

Source: adopted from Hutabarat, B. 1985

2.1.2. The Importance of Rice

Rice is the most important food commodity in the Indonesian economy. It is the major domestically produced staple foodstuff. The production, processing and distribution of rice is one of the largest primary sources of income and employment in the Indonesian economy. Rice production accounts for 72 percent of food crop sector GDP, for 11 percent of national GDP and 14 percent of non-oil GDP (World Bank (1987) in Tabor (1988)).

Rice is the main source of calories and protein in the Indonesian diet. It accounts for 60 percent of the total calories and more than 50 percent of the total protein in the diet. Moreover, rice accounts for a major share of total consumer expenditures. Private consumption expenditures in Indonesia are dominated by outlays on necessities, such as food, housing, clothing and education. Based on 1984 National Household Expenditure Survey (SUSENAS), as reported in Tabor (1988), food expenditures alone accounted for 55 percent of the total private consumption expenditures. Rice expenditure made up 45 percent of the total food expenditures. For the poorest population quartile, rice expenditures account for 58 percent of the total household expenditures.

Not only does rice expenditure use up a major part of the household budget, but rice is commonly used as the primary wage good of the economy. The direct consequence is that it is one of the cost push inflation factors. Beyond that, rice appears to have a psychological role in determining anticipated inflation and is considered a price leader by policy makers.

In rural areas of Java, production of rice is the main source of employment and incomes. According to the Ministry of Agriculture (1988), as reported by Tabor (1988), rice production is estimated to provide 9.4 million full-time person-years of employment each year. In 1986, income from rice production and distribution, valued in 1985 wholesale prices, was about 11,000 billion rupiah, or about ten billion U.S. dollars (the exchange rate in this period was roughly Rp 1100/US$).

Rice in Indonesia is considered a politically sensitive and strategic commodity. A national stockpile of rice is maintained and a National Logistics Agency (BULOG) is designated to handle this task as the sole importer and exporter of rice. The government provides large subsidies from its recurrent and development budget for irrigation investment and for the production and distribution of chemical fertilizers.

In Indonesia, rice is produced both in irrigated land (wetland) and in dryland. However, wetland rice production accounts for more than 90% of the total rice production. The yield of the wetland rice is much higher than that of dryland rice. This is not surprising since not only more government efforts are concentrated in the wetland rice production, but the dryland rice cultivation is dominated by subsistence farmers using traditional varieties with very simple cultivation and management practices. There is a distinct geographic distribution of rice production system in Indonesia. In 1982, for example, more than 62% of the total rice was produced in Java. Wetland rice is mostly cultivated in Java, which in 1983 accounted for more than 64% of total wetland rice production. On the other hand, about 70% of total dryland rice was produced off Java.

The total rice production, due to various government efforts and policies discussed later, has been increasing in the past few years with the annual growth rate 8.5% in the period of 1979-1982 and 5.1% in the period of 1982-1985 as presented in Table 2.3. This increase of the total rice production is mostly attributable to the significant increase in yield, for both wetland and dryland rice production. The annual growth rate of rice yield in the period of 1979-1982, for instance, was 7.8% for wetland rice and 5.6% for dryland rice. For the period 1982-1985, however, the growth rate of the rice yield declined significantly to only 4.8% for wetland and 2.6 for dryland rice.

Table 2.3. Area Harvested (000 Ha), Production (000 M.Ton) and Yield (00 Kg/Ha) of Wetland and Dryland Paddy in Indonesia (1979-1985).

	1979	1982	1985	growth rate* 1979-82	growth rate* 1982-85
Wetland Paddy					
Area Harvested	7,675	7,873	8,756	0.9	3.6
Production	24,732	31,776	37,027	8.7	5.2
Yield	32.22	40.36	42.29	7.8	4.8
Dryland Paddy					
Area Harvested	1,128	1,116	1,147	-0.4	0.9
Production	1,551	1,808	2,005	5.2	3.5
Yield	13.74	16.20	17.49	5.6	2.6
Total Paddy					
Area Harvested	8,803	8,988	9,902	0.7	3.3
Production	26,283	33,584	39,033	8.5	5.1
Yield	29.85	37.36	39.77	7.8	2.1

Source: CBS, Statistical Year Books of Indonesia
* computed from $V_t = V_0 (1+r)^t$

Although rice production has been increasing during the past two decades, it has not been sufficient to meet the total consumption of the country. Consequently, the country has been forced to import rice. During the period of 1968-1983, Indonesia was well known as the world's largest rice importing country. The significant growth in the total rice consumption is attributed to a rapid population growth and a steady improvement of the Indonesian people's living standard. Table 2.4 shows a steady increase in per capita rice consumption.

Since 1985 Indonesia has been a rice self-sufficient country. Despite this success, however, some potential problems still face the Indonesian government in the near future. A decreasing growth rate of the total rice production and steady growth rate of the population and the people's standard of living have recently led some Indonesian scientists to question the ability of the Indonesian government to maintain the rice self-sufficiency goal in the long run. Their concern comes at a time when budget constraints have forced the government to reconsider some of agricultural programs which were responsible for achieving the rice self-sufficiency goal.

The next section presents a brief overview of the past and current agricultural policies and programs. The recent policy issues which will be evaluated in this study will also be briefly outlined.

2.1.3. Past and Current Agricultural Policies

Until the late of 1970s, the primary objective of agriculture policy was to increase food, particularly rice, production in order to meet the accelerating growth of food consumption. Thus the policy target was very clear: to produce as much food as possible, regardless of any post-problems. Provincial targets for food production, by type of crop, were set annually, and all government efforts were focused on that target. A substantial portion of the government budget was devoted to obtain the target. No significant financial problems were facing the government, since as an OPEC member, the Indonesian government has been benefited from the monopolistic nature of the international oil market. Problems related to rice quality and inefficiency, among others, did not concern policy makers at that time.

Table 2.4. Per Capita Consumption and Food Balance Sheet for Rice (in Millions Tons)

Year	Production	Change in Stock	Waste Seed Feed	Import	Export	Available for Cons.	Per Cap. cons. (kg/year)
1970	13.05	0.22	1.87	1.18	0	12.13	104
1971	13.66	0.04	2.01	0.57	0	12.19	102
1972	13.24	-0.31	1.92	0.73	0	12.36	101
1973	14.45	0.32	2.06	1.71	0	13.78	110
1974	15.21	0.48	2.15	1.07	0	13.64	106
1975	15.19	0.09	2.15	0.67	0	13.63	104
1976	15.75	-0.14	2.21	1.29	0	14.96	112
1977	15.87	-0.05	2.23	1.96	0	15.65	114
1978	17.35	0.61	2.44	1.84	0	16.14	115
1979	17.84	-0.42	2.51	1.93	0	17.69	123
1980	19.97	1.27	2.82	2.03	0.01	17.89	122
1981	22.07	0.33	3.13	0.53	0	19.13	128
1982	22.78	0.11	3.20	0.30	0	19.77	129
1983	23.90	-1.08	3.38	1.15	0	22.76	145
1984	25.75	1.35	3.62	0.38	0	21.15	132
1985	26.47	-	3.72	0.03	0.27	22.52	137

Source: adopted from Tabor et al. (1988)

Several policies and programs deserve to be mentioned here. During the first half of the 1960s, rice production remained static while population grew very fast, resulting in a significant food shortages. Faced with this situation, the government has introduced nation-wide rice intensification programs which consist of the "mass guidance" program (BIMAS) started in the wet season 1964/1965, and the "mass-intensification" (INMAS), started in 1967. The BIMAS program embodies three basic principles (World Bank, 1978; Nestel, 1985): (i) the ideology of modern rice farming (PANCA-USAHA or five endeavors) which consists of: proper soil preparation, proper irrigation, improved seeds, proper fertilizer application and proper use of pesticides, (ii) credits to purchase a package of improved inputs (see appendix 2.1), and (iii) intensive guidance (extension) for participating farmers. The first and the third components are part of the INMAS program.

The introduction of the high yielding varieties (HYV) of rice and the continuous supply of highly subsidized inputs (fertilizers and pesticides) coupled with the rehabilitation, upgrading and expansion of irrigation systems were, among others, the major factors stimulating the increase of rice production in Indonesia. Rehabilitation and establishment of new transportation and other facilities were also undertaken as a set of extensive development strategies, especially in relation to dry-land development both on Java and off Java. All these efforts resulted in obvious benefits from the late 1960s to the late 1970s when the rate of growth of rice was as high as 8% annually.

Much of the previous success, however, did not persist and the rate of growth of rice has been declining. During the period of 1982-1985, for instance, the growth rate of rice production was 5% per year, declining to only 1.3% during the period of 1985-1987. Given this declining growth rate of the rice production and a steady population growth rate of 2.3%, it will not be too surprising if Indonesia, in the near future, returns to its former role as the world's largest rice importing country.

In addition to the rice self-sufficiency objective, there are three other objectives of the agricultural development in Indonesia (Nestel, 1985): (i) improvement of farm incomes and rural employment in the interest of achieving better income distribution within the society, (ii) provide urban consumers with rice at a "reasonable" and relatively stable price, and (iii) control the budget subsidies to producers and consumers which have been given in pursuit of the other objectives. These objectives are often in conflict with each other, in the sense that attaining more of one requires some sacrifice of another. A principle instrument in the pursuit of these objectives is pricing policy.

Rice was the first food commodity for which the government seriously intervened in the market. The basic philosophy of the rice price policy, as summarized by Mears (1981), was: (i) support for floor prices high enough to stimulate domestic production, (ii) ceiling price protection assuring a reasonable price for consumers, (iii) sufficient range between these two prices to provide traders and millers reasonable profit after holding rice between crop seasons, (iv) appropriate price relationships within Indonesia and internationally. In addition, inter-regional price spreads were intended to be sufficient to enable traders to cover costs of rice movement from surplus to deficit areas, and domestic prices were to be insulated from world prices to avoid large fluctuation in the domestic price.

The floor price of rice is set high enough to stimulate domestic production, improve farm income and promote rural employment. The floor price is determined on the basis of an incremental benefit-cost ratio that results from the participation in the BIMAS program. It is set annually such that the magnitude of the B/C ratio, as well as the rice-fertilizer ratio, is sufficient to induce farmers to join the intensification program. The ceiling price, on the other hand, is set low enough to provide a price subsidy to consumers and to contain the rate of inflation, but it is reasonable enough in order to provide incentives for trader. The prices of fertilizers and the floor prices of rough rice and rice are presented in appendix 2.2.

Since the basic philosophy of the government pricing policy was first implemented in the early 1970s, its application has evolved in response to changing circumstances and pressures. In particular, substantial economic and budget subsidies, especially for fertilizer, have been introduced, which to some extent have resulted in departures from the original principles of the rice price policy. Currently two types of subsidies are used, namely, budget subsidies which involve government cash payments from development budget, and economic subsidies which involve economic prices below the opportunity cost as reflected by long-run world prices (Nestel, 1985).

During the period 1970-1982, Indonesia generally maintained a domestic price for rice below the import parity price (see appendix 2.3). Only in 1976, 1977, and 1982, when the world price was well below its long-run trend level, was the domestic rice price above the import price (Nestel, 1985). The domestic prices of fertilizers are also kept well below their import parity prices. In 1982, for example, the economic prices (i.e., price in the absence of any subsidies) of urea and triple superphosphate (TSP) at the farm-gate were estimated to be Rp 160/kg and Rp 171/kg, respectively, compared to the official price of Rp 70/Kg (see appendix 2.4). Moreover, there is also an economic subsidy involved in the domestic production of urea, where the suppliers of natural gas for urea manufacture receive a price lower than the opportunity cost of that gas.

Although economic subsidies may involve efficiency costs for the economy, they do not necessarily involve cash outlays from the government budget. Specifically, differences between domestic and import parity prices will give rise to a budget subsidy only when rice or fertilizer is imported. Thus, imports of these commodities during 1970s, for example, were a substantial burden on the budget. Since Indonesia is now a competitive urea producer, and its urea production will continue to grow rapidly, no urea imports are needed in the coming years. The economic subsidy implicit in the low price of natural gas does not have a direct budget impact, rather it simply involves foregone revenues for the gas producer (the gas producer is a government owned enterprise).

The government budget for fertilizer subsidies consists of two main components: (i) the costs for selling urea and TSP fertilizers at prices considerably below the full production cost, (ii) the import costs for some imported fertilizers, including TSP. The 1981/1982 government budget for these subsidies was estimated to be US$ 370 million (appendix 2.5), which is equivalent to 30% of the total agricultural development budget. The other type of subsidy arises from the selling price of rice which does not reflect its full costs of storage and other marketing costs. In 1982, the price subsidy for rice consumers was estimated about Rp 30/kg.

Given the government's recent difficulties in raising the development budget in the one hand, and the developmental needs of other sectors in the economy in the other hand, attention is now focused on controlling subsidies such as fertilizer and rice price subsidies, which have a substantial impact on the government budget. A recent policy issue among Indonesian social scientists and policy makers is a general movement toward a phasing out all types of subsidies. The question effects of such policy changes on the rice production and consumption in general, on farm income, and on the real cost to the government, need to be carefully evaluated. As stated in the previous chapter, this study attempts to evaluate a small part of the above policy question.

2.2. Data Set

2.2.1. The survey

The data set used in this study was collected by the Agro Economic Survey, as part of the Rural Dynamic Study in the rice production area of the Cimanuk River Basin, West Java, and obtained from the Center for Agro Economic Research, Ministry of Agriculture, Indonesia.

Originally, the project was to be conducted over several consecutive years in order to observe individual farm response to economic and social stimulus. Farm household activities related to production, labor utilization, and consumption were to be continually monitored. Started in 1977, the project was terminated due to lack of funds, after having recorded two full crop years. The project was fortunately reinstated in 1983 in the same location and with the same farmers to cover the wet season of 1982/1983 and the dry season of 1983.

In 1977, the survey was conducted twice, that is at the beginning and the end of the year. The first survey gathered information on farming practices in the wet season of 1975/1976 and the dry-season of 1976. The second survey covered farm household activities in the wet season of

1976/1977. A similar survey was undertaken in 1978 to cover farm management activities in the dry season of 1977. The resurvey of 1983 to the same areas and same farmers was conducted with a different emphasis on labor utilization, asset holding, and land tenure arrangements.

2.2.2. The Survey Area and Sampling Procedure

The survey area, which is the rice production area in the Cimanuk river basin, is characterized by irrigated rice farms and an almost uniform agroclimate. It covers six desa (villages) located in five kabupaten (the administrative unit between district and province level), namely: desa Wargabinagun in kabupaten Cirebon, desa Lanjan in kabupaten Indramayu, desa Gunung Wangi and Malausma in kabupaten Majalengka, desa Sukaambit in kabupaten Sumedang and desa Ciwangi in kabupaten Garut.

The six sample villages were drawn using a multi-stage stratified random sampling, based on the following four criteria: (i) percentage of irrigated sawah (paddy field), (ii) latitude stratum, (iii) accessibility to transportation, and (iv) proximity to township (Hutabarat, 1985). In addition, the desa selection was also based on the consideration to cover all five kabupaten.

From each desa, 60 farmers were randomly drawn from four farm size strata, 15 farmers each, namely (i) below 0.25 ha, (ii) 0.25 to 0.50 ha, (ii) 0.5 ha to 1 ha, and (iv) above 1 ha. The attempt was to get a better representation of the farm households in the survey area. In practice, the number of farmers recorded in each season varied between and within villages.

2.2.3. The Panel Nature of the Data

The data set generated by the survey is commonly referred to as a panel data set, since the individual farmer was observed over time. This data set will be used in its advantage manner, that is in the framework of panel data analysis discussed in the next chapter. To date, several studies have used these data. However, these studies, Sugianto (1982), Hutabarat (1986) and Gunawan (1987) among others, analyzed these data using separate cross-sectional analysis or by simply pooling the data

The analysis of this study uses the so called balance design, where individuals are observed for the same lengths of time. Using the individual identification number to check and match individual respondents, only 171 respondents were found to have been continuously recorded for six seasons (Table 2.5). Some respondents, for various reasons, were replaced by the new ones in the next survey. Others were not recorded in a particular planting season since they were absent. All these respondents were excluded from the analysis. Some respondents were also excluded from the analysis because of incomplete information associated with them. It is possible, of course, to analyze panel data where individuals are observed for different lengths of time, that is $t=1,2....T_i$, where i is individual's subscript, which commonly referred to as imbalance design. Due to its potential computational difficulties, however, this study does not use this approach. In addition, the balance design is much simpler computationally, and the number of individuals is large enough to obtain reasonable degrees of freedom.

Table 2.5. Number of respondents in each Sample Village

Desa (Village)	Kabupaten (Regency)	Number of Observation
Wargabinangun	Cirebon	19
Lanjan	Indramayu	24
Gunung Wangi	Majalengka	37
Malausma	Majalengka	33
Sukaambit	Sumedang	22
Ciwangi	Garut	36
Total Observations		171

2.2.4. Sample Village Characteristics

This section attempts to provide a brief description of the sample village characteristics. This is important since it is hypothesized that the variation of the level of production and profit is associated with the region where the individual farmer lives. Regions can be regarded as individual non-specific time invariant variables in the framework of panel data analysis. It should be noted that the description presented here is based on the information gathered in the first survey in 1976, and may differ from the present situation.

Table 2.6 presents village characteristics in terms of available land types. As noted earlier, sample villages were selected such that they best represented irrigated rice farming in West Java. Three villages

(Wargabinangun, Lanjan and Gunungwagi) can be considered as lowland areas while the other three (Malausma, Sukaambit and Ciwangi) can be considered as highland areas. The following is the brief description of each village.

Table 2.6. Land Use Characteristic of the Sample Village

Desa	% Irrigated land	% Dryland & Others	Total Area (Ha)
Wargabinangun	95	5	302
Lanjan	80	20	125
Gunung Wangi	56	44	338
Malausma	16	84	909
Sukaambit	30	70	578
Ciwangi	17	83	1726

<u>Wargabinangun</u>

This village is relatively remote and difficult to reach since no public transportation connects this village to other villages. The village roads are unpaved and were constructed by local villagers. During the wet (rainy) season these roads are almost impassable. Bicycle is the main form of transportation for villagers.

The village can be classified as a lowland area with an average altitude of 10-15 meters. As indicated in Table 2.2, this village is dominated by irrigated rice farms. Rice farming in this village, however, is not without problems. Poor drainage and water control are problems regularly faced by farmers. During the wet season flooding is almost always a problem, while during the dry season most paddy fields lack irrigation water.

There is no permanent local market available in the village. Farmers sell their products to small traders, often referred to as collectors, who periodically come to the village, particularly during harvest season.

Most farmers cultivate TV, since HYVs are known not to grow optimally under local conditions. In addition, farmers prefer the taste of TV rice. In the past rice was only planted once a year, but since 1968 farmers now plant twice a year.

Lanjan

Lanjan is located in the northern part of West Java along the major Kerawang-Jakarta highway and thus is much more accessible than Wargabinangun. Unlike Wargabinangun, year-round public transportation is available.

The village is relatively small, 125 ha total area, of which 80% is irrigated sawah and 20% is dryland. Most of the sawah can be cultivated with paddy twice a year; the remainder, due to water control problems, is cultivated only once a year. Rice is grown primarily on small farms with 60% of farms being less than one hectare. Interestingly, only 27% of the land is owned by villagers, the rest is owned by people outside the village. The majority of villagers are landless farm laborers.

Farmers purchase fertilizer and other production inputs from either the village cooperative unit (KUD/BUUD) as part of BIMAS credit or from a local retailer. The retailer's price of fertilizer was lower than the cooperative's price.

It should be noted that Lanjan is characterized by seasonal migration. During the harvest season, when employment opportunities in the village decline, some villagers temporarily leave to seek harvesting jobs in other villages and even other kabupaten. They move from one village to another until the harvest season ends. During the dry season, when there are no longer field activities available, they migrate to nearby cities such as Kerawang, Bekasi or even Jakarta to get temporary jobs, particularly as construction workers.

Gunung Wangi

Gunung Wangi can be classified as a highland area, with the average altitude 875 meters. It is relatively remote, about 14 km away from the nearest kecamatan (district) town. Although available, transportation facilities are relatively poor, especially during the rainy season.

This village covers 338 hectares, of which 189 hectares are sawah and 144 hectares are dryland. Most of the sawah can be cultivated with paddy twice a year. Traditional varieties of rice are commonly grown. Sawah in the village is irrigated by a local irrigation facility and irrigation water from the mountain and is available year round. Fertilizer is obtained as part of the BIMAS package, and since farmers grow TV rice, they receive package-B (150 kg/ha urea, and 50 kg/ha TSP). Farmers feel this amount of fertilizer is insufficient, and purchase additional amounts of fertilizer from local private retailers.

The majority of villagers are farmers some of whom are landless farm laborers. There is no evidence of out-migration from the village, but there is strong evidence of in-migration. Gunung Wangi has no permanent local market, so farmers rely on local or out-of-village traders who come periodically to collect agricultural produce.

Malausma

Malausma is located about 12 km away from the district capital. It is a mountainous area with the altitude ranging from 600 to 1100 meters. This village has paved all-weather village roads. Public transportation is available, making this village highly accessible.

The village covers 909 hectares, consisting of 150 hectares of irrigated sawah and the remaining area of dryland. Unlike other villages covered in the survey, most villagers are involved in small-scale home industry as well as working part time on their farms. Only about 34% of the villagers are involved purely in farming. Irrigated sawah is cultivated twice a year with both TV and HYV rice, while the dryland is planted to rice once a year which is then followed by secondary crops. Most of the rice is produced for own-consumption and the rest is sold to the rice hullers owners or to local traders.

Fertilizer and other production inputs are obtained from the village cooperative unit, as part of the BIMAS credit or the INMAS program. These inputs can also be purchased from the local retailers at slightly higher prices.

Sukaambit

Sukaambit is about 10 km away from the capital of kabupaten Sumedang. Public transportation connecting the village to other villages and to the capital of the kabupaten is available. Thus there is no transportation problem. Moreover, although no village market is available, there are many small retailers, selling all basic needs and agricultural inputs. With an average altitude of 375 meters, it is not clear whether the village should be categorized as a lowland or a highland area.

Sukaambit covers 578 hectares, of which 70% is dryland and 30% is sawah. Rice, both TV and HYV, is cultivated twice a year. Some farmers follow a cropping pattern of rice-rice-secondary crops, but most (72%) follow a rice-rice pattern. Only 10% of sawah is cultivated with rice once a year. Vegetables are also grown in this village, particularly in the dryland area.

Most of the rice produced is for home consumption, with only a small part sold to the local traders or rice huller owners in the village. Since no local market is available, farmers usually sell their farm products to the market in kecamatan. Fertilizer and other inputs are obtained from the village unit as part of BIMAS credit or purchased from the local retailers or retailers in kecamatan.

Ciwangi

Ciwangi is located about 3 km away from the district capital. It can be classified as a highland area with the average altitude of 700 meters. Village roads connecting the village to district capital can be used by trucks or other small vehicles year round. Thus the village is highly accessible.

This village covers 1726 hectares consisting of 83% dryland and 17% irrigated sawah. Most of the sawah is planted with rice twice a year. Water for the local irrigation facilities is obtained from a small river in the village and from a nearby mountain, but is not always available during the dry season. HYV rice has been widely adopted by farmers in this village.

Farmers under the BIMAS program obtain fertilizers and other inputs from the village cooperative unit, while non-BIMAS farmers purchase production inputs from local or kecamatan retailers. Farm products are sold either to local traders or at the district capital market.

The majority of villagers (80%) are involved in farm activities. Temporary or seasonal migration is common, particularly for those who work as traders.

III. LITERATURE REVIEW AND ANALYTICAL FRAMEWORK

This chapter reviews the literature related to the analytical framework used in this study. It consists of seven sections, and is organized as follows. The first section provides a brief review of panel data literature, followed by section two which reviews literature related to production function and efficiency concept. Section three presents a short review of the dual theory of the production function, that is profit function approach, along with the derivation of output supply and input demand. Section four presents a derivation of stochastic profit frontiers, followed by section five which reviews stochastic frontier models in relation to panel data. A literature review of the multinomial logit model, which will be used to identify factors affecting the adoption of new rice varieties, is described in section six. Finally, section seven presents a brief review on the framework of agricultural and food policy evaluation in general, particularly related to price support and input subsidy policies.

3.1. Panel Data

A panel data set, that is a cross section of individuals observed over time, provides additional observations and new sources of variation in the exogenous variables; in particular, variation between individuals and variation within individuals over time become distinguishable. In principle, this leads to more efficient estimates of the common parameters. More importantly, panel data also make possible consistent estimation when unobservable factors, specific to time or to individual, are thought to be correlated with other explanatory variables.

When panel data are used, one of the ultimate goals is to use all available information to make inferences on the parameters of interest. A simple model commonly postulated is that dependent variable (Y) is a linear function of the regressors (X). To run a least-squares (LS) regression with all observations (pooled), one needs to assume that the regression parameters take values common to all cross-sectional units for all time periods. If this assumption is not valid, the pooled LS estimates may lead to false inferences.

One of the most simple models to take account of heterogeneity across individuals and/or through time is to use the variable-intercept models. The basic assumption of such a model is that, conditional on the observed explanatory variables, the effects of all omitted variables are driven by the following three types of variables (Hsiao, 1986): (i) individual time-invariant variables that are the same for a given cross-sectional unit through time but vary across cross-sectional unit, such as individual firm management ability, sex, and socioeconomic variables, (ii) period individual-invariant variables that are the same for all cross-sectional units at a given point in time but that vary through time, such as prices, interest rates, and widespread optimism and pessimism, and (iii) the individual time-varying variables that vary across-sectional units at a given point in time and also exhibit variation through time, for examples: firm profits, sales, capital stocks.

The variable-intercept models can provide a fairly useful specification for fitting regression models using panel data. Let consider the following model (Hsiao, 1980):

$$Y_{it} = a_0 + \Sigma_k a_k X_{kit} + e_{it} \tag{3.1}$$
$$e_{it} = uM_i + zP_t + v_{it}$$

where $i=1,2...N$ refers to a cross-sectional unit or individual, $t=1,2...T$ refers to a given time period, M_i and P_t are individual- and time-effects variables while v_{it} represents the effects of all remaining omitted variables. Unfortunately, there usually are no observations on M_i and P_t. It is, therefore, impossible to estimate u and z directly. A natural alternative would then be to consider the effects of the product, $u_i = uM_i$ and $z_t = zP_t$, which then leads to a variable-intercept model.

There are two basic approaches in treating the effects, that is to consider them as fixed or random. The fixed-effects model is viewed as one in which the investigator makes inferences conditional on the effects that are in the sample. The random-effects model is viewed as one in which the investigator makes unconditional or marginal inferences with respect to the population of all effects. It is the investigator's choice to decide whether to make inference with respect to the population characteristics or only with respect to the effects that are in the sample, and it depends on the context of the data, the manner in which they were collected, and the environment from which they came.

The following presentation is on the variable-intercept model, as this study will be using. More specifically, it is the model with constant slope coefficients and an intercept that varies over individuals but is constant over time. A varying intercept term is assumed to capture differences in behavior over individuals (individual effects). The presentation in this section drawn heavily from Judge et al.(1982), Judge et al.(1985), and Hsiao (1986).

Equation (3.1) can be rewritten as

$$Y_{it} = a_{oi} + \Sigma_k a_k X_{kit} + v_{it} \tag{3.2}$$

where (i) i and t are defined as in equation (3.1), (ii) Y_{it} is an observation on the dependent variable for the i^{th} individual and t^{th} time period, (iii) X_{kit} is an observation on the k^{th} explanatory variable for the i^{th} individual and t^{th} time period and assumed non-stochastic, (iv) v_{it} is the random error for i^{th} individual and t^{th} time period and is assumed to have zero mean and constant variance and independently distributed over time and individuals, (v) a_k, k=1,2...K, are the slope coefficients which are assumed to be constant over time and individuals, and finally (vi) a_{oi}, i=1,2...N are the intercept terms that are assumed to be different for each individual but constant over time.

3.1.1. Fixed Effect: Dummy Variable Model

In this section we consider the model in equation (3.2) with the assumption that a_{oi} are fixed parameters and v_{it} are independent and identically distributed with $E[v_{it}]=0$ and $E[v_{it}^2]=\sigma_v^2$. This model is often known as a dummy variable model since it is possible to rewrite it as

$$Y_{it} = \Sigma_j a_{oj} D_{jt} + \Sigma_k b_k X_{kit} + v_{it} \tag{3.3}$$

where the D_{jt} are dummy variables and take values zero or one, that is D_{jt} equals to 1 if j is i and equals to zero if j is not i. Using a Kronecker product notation, the complete set of NT observation can be written compactly as

$$Y = [\ I_N \otimes J_T \quad X_s\ ] \begin{bmatrix} a_o \\ a_s \end{bmatrix} + v \tag{3.4}$$

where $Y'=(Y_1',\ldots Y_N')$, $X_s'=(X_{s1}',..X_{sN}')$, $v'=(v_1',..v_n')$, $a_o=(a_{o1},\ldots a_{oN})$, $a_s'=(a_1,\ldots a_k)$, $\otimes$ is a symbol of Kronecker product, J_T is a (Txl) vector of ones and $I_N \otimes J_T$ is a the (NTxN) matrix of dummy variables.

Theoretically, given the above assumptions of v and X_s, there is no estimation difficulties since the LS estimator can directly be applied and it is best linear unbiased. However, there could be numerical problems, if there are many individuals (N large) since the inversion of matrix (N+K) may become unreliable. Under these circumstances it is advisable to estimate a_o and a_s using partitioned inverse as

$$\hat{a}_s = (X_s'(I_N \otimes D_T)X_s)'\ X_s'(I_N \otimes D_T)Y \tag{3.5a}$$

$$\hat{a}_{oi} = \underline{Y}_{i.} - \underline{X}_{i.}'\ \hat{a}_s \tag{3.5b}$$

where

$$D_T = I_T - (J_T J_T)/T$$

$$\underline{Y} = 1/T\ \Sigma_t\ Y_{it}$$

$$\underline{X}_{ki.} = 1/T\ \Sigma_t\ X_{kit}$$

$$\underline{X}_{i.} = (\underline{X}_{1i.}',\ldots\ldots..\underline{X}_{Ki.}')$$

Matrix D_T is idempotent. When it is used to transform the observations on the i^{th} individual, it has the effect of expressing each variable in terms of its deviation from the mean. The LS estimator of the slope coefficient $\hat{a}_s$ in the dummy variable model is obtained by simply applying

LS to the transformed model, that is

$$(Y_{it} - \underline{Y}_{i.}) = \Sigma_k a_k (X_{kit} - \underline{X}_{ki.}) + (v_{it} - \underline{v}_{i.}) \tag{3.6}$$

This estimator is often referred to as least-squares dummy variable (LSDV) estimator or covariance estimator. It is also called the "within" estimator since it utilizes variation within individuals.

It is worthwhile to note the estimation of σ_v^2. Both the LS with dummy variable and the "within" procedures lead to the same residual vector. The unbiased estimator of σ_v^2 is computed by dividing the residuals sum of squares (SSE) by (NT-N-K), which is obtained by simultaneously estimating a_0 and a_s. However, if we use the "within" transformation technique the variance estimator is biased, since it is a division of SSE by (NT-K). Under these circumstances it is advisable to correct this estimator by multiplying it by (NT-K)/(NT-N-K) (Judge et al., 1982).

Statistical tests can be performed to test the null hypothesis that individuals have the same intercepts against the alternative hypothesis that they are not the same. One can compute relevant F statistic using restricted and unrestricted SSE as

$$F = \frac{(SSE_R - SSE_{UR})/(N-1)}{SSE_{UR}/(NT-N-K)} \tag{3.7}$$

where R and UR stand for restricted and unrestricted, (N-1) is the number of restrictions and (NT-N-K) is number of degrees of freedom in the unrestricted model. Under the null hypothesis this statistic has an F distribution with (N-1) and (NT-N-K). In applied work judgments are frequently made whether some dummy variables should be excluded by examining the t values associated with individual coefficients. Such a practice, however, is not recommended (Judge et al., 1982).

3.1.2. Random Effect: The Error Component Model

We again consider the same model as in equation (3.2). Instead of assuming that a_{0i} are fixed coefficients, we now assume that they are independent random variables with a mean a_0 and variance σ_u^2. The model can be rewritten as

$$Y_{it} = a_0 + \Sigma_k a_k X_{kit} + u_i + v_{it} \tag{3.8}$$

when written in matrix notation this becomes

$$Y_i = X_i a + u_i J_T + v_i \tag{3.9}$$

where Y_i, J_T and v_i were previously defined. $X_i=(J_T\ X_{si})$ is a Tx(K+1) matrix of observations of the explanatory variables including the constant term for the i^{th} individual and $a'=(a_0, a_1,\ldots a_k)$. The term $(u_i J_T + v_i)$ can be regarded as a composite disturbance vector that has mean zero and covariance matrix

$$\begin{aligned} V &= E[(u_i J_T + v_i)(u_i J_T + v_i)] \\ &= \sigma_u^2 J_T J_T' + \sigma_v^2 I_T \end{aligned} \tag{3.10}$$

$$= \begin{bmatrix} \sigma_u^2+\sigma_v^2 & \sigma_u^2 & \cdots\cdots & \sigma_u^2 \\ \sigma_u^2 & \sigma_u^2+\sigma_v^2 & & \sigma_u^2 \\ \sigma_u^2 & \sigma_u^2 & \cdots\cdots & \sigma_u^2+\sigma_v^2 \end{bmatrix}$$

The structure of this covariance matrix is such that, for a given individual, the correlation between any two disturbances in different time periods is the same. Thus in contrast to a first-order autoregressive model, the correlation is constant and does not decline as the disturbance become farther apart in time. Another feature of this covariance matrix is that it does not depend on i, and is identical for all individuals.

The complete set of NxT observations can be presented more compactly as

$$Y = X\,a + u \otimes J_T + v \tag{3.11}$$

with the covariance matrix $\Omega = I_N \otimes V$, which is block diagonal with each block given by equation (3.10). The block diagonal property arises because the disturbance vectors corresponding to different individuals are assumed to be uncorrelated.

It is clear that the covariance matrix for the error component model is not of the scalar-identity type, and consequently although the LS applied directly to (3.11) is unbiased, there is a question whether it still remains best. This because the covariance matrix of the estimates will likely be biased, either understating or overstating the true variances and covariances. If σ_u^2 and σ_v^2 are known, the generalized least squares estimator (GLS) is relevant in this instance and it is the best linear unbiased estimator. The GLS estimator is

$$\hat{a} = (X' \Omega^{-1} X)^{-1} X' \Omega^{-1} Y \tag{3.12}$$

If we partition this estimator as $\hat{a}' = (\hat{a}_0\ \hat{a}_s')$, it is possible to show that $\hat{a}_s'$ is a matrix weighted average of the "within" estimator and another estimator which is known as the "between" estimator (Judge et.al, 1985; Hsiao, 1986). The latter is obtained by running the LS regression of the individual means, that is by averaging equation (3.2) over time. The weights are the inverses of the covariance matrices of the respective estimators. Thus the GLS estimator can be viewed as an efficient combination of these two estimators.

The easiest way to obtain the GLS estimator is by transforming the data by a transformation matrix P, where P is such that $P'P = c\Omega^{-1}$ and c is any scalar, and then running the LS regression of the transformed data using a standard LS computer package. Fuller and Battese (1973) suggest the transformation matrix $P = I_N \times P_i$, where

$$P_i = I_T - (1 - w)\ J_T J_T / T \tag{3.13}$$

where $w = \sigma_v / \sigma$ and $\sigma^2 = T\sigma_u^2 + \sigma_v^2$. $P_i' P_i = \sigma_v^2\ \Omega_i^{-1}$ and hence $P'P = \sigma_v^2\ \Omega^{-1}$.

In practice, the transformed observations are simply obtained by (i) calculating the individual means for each variable, and then (ii) expressing the observations in terms of deviations from a fraction θ, where $\theta = 1 - w$, of their individual means. For the constant term this means replacing a column of ones with a column containing the constant $(1 - \theta)$. The GLS estimator is obtained by applying LS regression on the transformed data, that is

$$(Y_{it} - \theta \underline{Y}_{i.}) = (1 - \theta)a_0 + \Sigma_k (X_{kit} - \theta \underline{X}_{ki.})a_k + (v_{it} - \theta \underline{v}_{i.}) \tag{3.14}$$

It is obvious that if $w \rightarrow 1$ or $\theta \rightarrow 0$ the GLS estimator ($\hat{a}_k$) converges to OLS estimator, while if $w \rightarrow 0$ or $\theta \rightarrow 1$ it converges to covariance or within estimator (equation 3.6). In essence, w measures the weight given to the between-individual variation. In the covariance procedure, this source of variation is completely ignored. The OLS procedure, on the other hand, takes this source of variation completely by adding it to the within-individual variation. Thus, we can view OLS and covariance procedures as somewhat all-or-nothing ways of utilizing the between-individual variation (Hsiao, 1986).

If σ_v^2 and σ_u^2 are unknown we can not use the above GLS estimator. However, it is possible to replace them with their estimates. When this is done the resulting estimator ($\hat{a}^*$) is often called the estimated generalized least squares (EGLS)

$$\hat{a}^* = (X' \Omega^{*-1} X)^{-1} X' \Omega^{*-1} Y \tag{3.15}$$

A large number of alternative estimators for σ_u^2 and σ_v^2 have been documented in literature (Judge et.al, 1985). One method for obtaining unbiased estimators of these variances is to use the residuals from the "within" estimator to estimate σ_v^2 and the residuals from the "between" estimator to estimate σ^2.

The EGLS can briefly be summarized in the following steps:

(1) Calculate the dummy variable estimator or the "within" estimator.

(2) Use the residuals in step 1 to estimate

$$\sigma_v^2 = SSE/(NT-N-K) \tag{3.16}$$

(3) Calculate the "between" estimator, that is LS regression using the observations on the individual means.

(4) Use the residuals from step 3 to estimate

$$\sigma^2/T = SSE/(N-K-1) \tag{3.17}$$

It is worthwhile to note that the between estimator can be performed by using NT rather than N observations, that is by repeating each of the N individual means T times. This practice will not change the estimator, but it will make SSE T times larger. In this case we estimate σ^2, not σ^2/T.

(5) Calculate the estimator for the σ_u^2 as

$$\sigma_u^2 = (\sigma^2 - \sigma_v^2)/T \tag{3.18}$$

The disadvantage of this estimator is the possibility of a negative σ_u^2.

(6) Calculate the weight as $\theta = 1 - w$, where $w = \sigma_v/\sigma$

(7) Transform the original observations using θ and the individual means

(8) Run a LS regression on the transformed observation as in equation (3.14)

The best linear unbiased predictor of the random components u_i can be obtained by using the following formula (Lee and Griffiths, 1979)

$$\hat{u}_i = (T\sigma_u^2 / \sigma^2)(\underline{Y}_{i.} - \hat{a}_0 - \Sigma_k \hat{a}_k \underline{X}_{ki.}) \tag{3.19}$$

This prediction is sometimes of interest since it gives information on the future behavior of individual.

To test the presence of individual random effects, that is to test the null hypothesis that $\sigma_u^2 = 0$, one can use the Lagrange Multiplier test suggested by Breusch and Pagan (1980) as follows

$$LM = \frac{NT}{2(T-1)} \left[\frac{\Sigma_i (\Sigma_t \hat{e}_{it})^2}{\Sigma_i \Sigma_t \hat{e}_{it}^2} - 1 \right]^2 \tag{3.19}$$

Under the null hypothesis this statistic is asymptotically distributed as $Chi^2(1)$, where $\hat{e}$ is the vector of LS residuals obtained by regressing Y on X (equation 2.8).

3.1.3. Fixed or Random Effects

Whether to treat the individual effects as fixed or random is not an easy question to answer. It can make a surprising amount of difference in the estimates of the parameters in the cases where T is small and N is large (this is the case of the panel data of this study). There are two strong opposing arguments.

Advocates of the random effect model will argue that if the effects of omitted variables can be appropriately summarized by a random variable and the individual (or time) effects represent the ignorance of the investigator, it does not seem reasonable to treat one source of ignorance (u_i) as fixed and the other source of ignorance (u_{it}) as random. It appears that one way to unify the fixed-effects and random-effects models is to assume from the outset that the effects are random.

Mundlak (1978) criticized the random effects formulation on the grounds that it neglects the correlation that may exist between the individual effects (u_i) and the explanatory variables (X_{it}). There are reasons to believe that in many circumstances these two are correlated. For instance, the output of each firm (Y_{it}) may be affected by unobservable managerial ability (u_i). Firms with more efficient management tend to produce more and use more inputs (X_i), while less efficient firms produce less and use fewer inputs. Ignoring this correlation leads to biased estimates of the parameters.

One way to decide whether to use a fixed effects or random effects model is to test the null hypothesis that there is no correlation between the individual effects and the included explanatory variables against the alternative hypothesis that such correlation exists. For this purpose, we can use either Hausman test (1978) or an asymptotically equivalent test suggested by Mundlak (1978). If the null hypothesis holds we use the random-effects model, otherwise we use the fixed-effect model.

The Hausman test is basically as follows. Under the null hypothesis, $E[X'u]=0$, the GLS estimator should not be significantly different from the covariance estimator. Provided no other classical assumptions are violated, a statistically significant difference of these two estimators indicates that the alternative hypothesis holds, that is $E[X'u]$ is different from zero. Hausman takes the difference of these two estimators, say $\hat{q}$, and its variance, var($\hat{q}$), as a basis for the relevant test statistic. Var($\hat{q}$) is simply the difference between the variance of these two estimators, since the covariance of these two is zero. The test statistic is

$$\hat{q}'[\ \mathrm{Var}(\hat{q})\ ]^{-1}\ \hat{q} \tag{3.20}$$

where the null hypothesis is distributed as $\mathrm{Chi}^2(K)$ and K is the number of explanatory variables (excluding the constant term).

The Mundlak test is an F test based on the residuals from transformed equation (3.14) and the residuals from its modification as

$$Y^* = X^*a + \bar{X}b + v^* \tag{3.21}$$

where $\bar{X}$ is a matrix of the individual means of included explanatory variables (Kmenta, 1986). The test of the null hypothesis is therefore a test of significance of b, which is a standard F test.

3.1.4. Seemingly Unrelated Regression (SUR) With Error Component

The concept of an error components model can be generalized beyond a single equation. Given a set of panel data, for example, one might wish to estimate a system of consumer demand equations or to estimate a system of equations consisting of profit (cost) function and factor share equations. Single equation error component procedures outlined in the previous section can not be used to obtain efficient parameter estimates of a system of equations unless error correlations between equations are assumed to be zero.

The derivation of the GLS estimator of SUR with an error component can be found in Avery (1977) and in Baltagi (1980). The problem with this estimator, particularly for applied users, is that no ready computer packages are available at this time. Moreover, the transformation matrix to allow the use of standard LS computer packages is apparently very complicated and is not yet in the literature. The only way, at this time, is to write the necessary computer program.

3.2. Production Function and Efficiency

A production function describes technical relationships that transform inputs into outputs. It also shows the maximum possible output (frontier) attainable from a given combination of inputs. There cannot be any point above the production frontier. The distance a firm lies below its production frontier measures the level of inefficiency.

A production process can be inefficient in two ways. It is technically inefficient if it fails to produce maximum output from a given input bundle. It is price or allocatively inefficient if the marginal revenue product of an input is not equal to the marginal cost of that input, resulting in utilization of inputs in the wrong proportions for given input and output prices. A combination of these two is usually referred to as total productive or economic inefficiency.

There is, however, a discrepancy between the above definition and the one that is statistically estimated. The latter, which is usually referred to as a "non-frontier" or an "average" production function and estimated by ordinary least square (OLS), allows some firms to be above the "fitted" function. One can use the "average" function to estimate technical inefficiency under a certain restrictive assumption. The result, however, cannot be called a pure measure of technical inefficiency since it also includes random variability. The frontier production function is designed to bridge the gap by introducing the error term to represent an (in)efficiency measure.

Forsund, Lovell and Schmidt (1980), in their survey on frontier production functions, distinguished between best practice frontiers and absolute frontiers. The former is estimated by those methods which fit a frontier without assuming the form of the distribution of the one-sided error. Consequently, the former yields 100% efficient firms. The latter does not yield 100% efficient firms since it is defined with respect to all the firms which could conceivably exist and embody current technology.

3.2.1. Deterministic Non-Parametric Frontier

The concept of frontiers and efficiency measurement in production theory was initiated by Farrel (1957). His measure of technical and allocative inefficiency is defined in terms of a non-parametric and deterministic framework. In this approach output is assumed to be bounded by a deterministic production function. With the assumption of constant returns to scale, the production technology can be fully characterized by a unit isoquant. Since the efficient unit isoquant is unobservable, it has to be estimated from the observed input-output ratios of a sample firms by linear (mathematical) programming techniques subject to the restriction that no observation on the input-output ratio can lie below the isoquant.

The principal advantage of the approach is that no functional form is imposed on the data. The disadvantage is that the assumption of constant returns to scale (CRS) is restrictive, and its extension to non-CRS is cumbersome. The other disadvantage is that the frontier is constructed from a supporting subset of observations from the sample, and is therefore susceptible to outliers and measurement errors.

3.2.2. Deterministic Parametric Frontier

In view of the difficulties in the non-parametric approach, Farrel proposed computing a parametric convex hull of the observed input-output ratios. Aigner and Chu (1968) were the first to follow Farrel's suggestion. They estimated a CD function:

$$\ln y = a_0 + \Sigma_i a_i \ln x_i + u, \qquad u \leq 0 \tag{3.22}$$

by programming methods, i.e., linear programming and quadratic programming. Once the parameters are estimated, technical inefficiency for each firm can be computed directly from the residuals.

The principal advantage of the parametric approach compared to the non-parametric approach is the ability to accommodate non-CRS. The problem is the specification of functional form which often imposes a limitation on the number of observations that can be technically efficient. In the homogenous CD case, for example, when linear programming algorithm is used, there will in general be only as many technically efficient observations as there are parameters to be estimated. Like the non-parametric approach, this is very sensitive to outliers. One possibility to improve the estimates, suggested by Aigner and Chu and implemented by Timmer (1971), is to discard some extreme (most efficient) observations until the resulting estimates stabilize. If the rate of change of the estimates with respect to succeeding deletions of observations diminishes rapidly, this suggestion will be useful. Finally, a common problem of all the non-statistical models is that the estimators do not possess any statistical properties so that inferential results cannot be obtained.

3.2.3. Deterministic Statistical Frontiers

In the Aigner-Chu model, once some distributional assumptions are made on the one-sided error u, it becomes a statistical frontier model. The usual assumptions are (i) u is independently and identically distributed with finite mean and variance, (ii) u is uncorrelated with x_i's. Under these assumptions OLS gives consistent estimators of all parameters except a_0. A consistent estimator of a_0 can be obtained once some distributional assumption is imposed on u. This is sometimes referred to as corrected OLS (COLS) originally proposed by Richmond (1974).

The difficulty with the COLS approach is that we can get residuals, which are our estimates of inefficiency, with the wrong sign. One way of resolving the problem is to correct the estimate of a_0 in such a way that no residual is positive and one is zero. This amounts to assuming that one firm is 100 percent efficient and then measuring the efficiency of other firms relative to this one. Another difficulty with the COLS methods is that the correction to a_0 is dependent of the distribution of u. For example, the gamma and exponential distributions yield systematically different corrections for a_0, and systematically different estimates of technical inefficiency, except for the special case when variance of u is one (Forsund et al., 1980).

3.2.4. Stochastic Statistical Frontiers.

In the deterministic model the variation in firm performance relative to the frontier is attributed to inefficiency, thereby ignoring the possibility of variation due to factors not under the control of any firm such as weather variation, machine breakdown, luck, which is usually referred to as statistical noise. Combining these two together, as in deterministic frontiers, and labelling it as inefficiency is not appropriate. The statistical noise needs to be separated from the controllable factors that are designated as inefficiency. This is the essential idea behind the stochastic production frontier model developed independently by Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977). Their model, which can also be referred to as a composed error model, is stochastic in a sense that it captures exogenous shocks beyond the control of firms. The model is as follow:

$$Y_i = f(X_i;B) + e_i \tag{3.23a}$$

where Y_i is the maximum amount of output obtainable from X_i, a vector of non-stochastic productive inputs of the i^{th} firm, and B is a vector of unknown parameters to be estimated. In addition

$$e_i = v_i - u_i \tag{3.23b}$$

where v_i, the error component representing random noise, is assumed to be distributed normally with zero mean and variance of $\sigma_v{}^2$, while u_i, the non-negative error component representing technical inefficiency, is assumed to be distributed either with a "half normal" density or with an exponential density, both with mode at u=0.

The major weakness of the model is its difficulty in estimating individual inefficiency although average inefficiency for the population and its variance are available as

$$E[u] = \underline{u} = \sigma_u \, (2/\pi)^{0.5} \tag{3.24a}$$

$$V(\underline{u}) = \sigma_u^{\,2} \, (1 - 2/\pi) \tag{3.24b}$$

Jondrow, Lovell, Materov and Schmidt (1982) show that by assuming v_i is normal and u_i is positive half-normal, v_i and u_i are independent, and that inefficiency is independent of the regressors, then an estimate of the individual inefficiency for each firm can be obtained, although not consistently. The estimate u_i is based on the conditional mean of u_i given e_i, that is:

$$E(u_i/e_i) = \sigma^* \, [f(e_i \; s/\sigma^*)/(1-F(e_i \; s/\sigma^*)) \,] - e_i \,/\sigma^* \tag{3.25}$$

where

$$\sigma^* = (\sigma_u^{\,2} \, \sigma_v^{\,2})(\sigma_u^{\,2} + \sigma_v^{\,2})^{-1}$$
$$s = \sigma_u^{\,2} \,/\, \sigma_v^{\,2}$$

The symbols f and F represent the standard normal density (pdf) and cumulative distribution function (cdf), respectively. By replacing e_i with its estimate ($\hat{e}_i$) and σ^*, s by their estimates, one can estimate u_i. Using this method Bagi and Huang (1983), as cited in Seale (1985), estimate individual efficiency for 193 farms in Tennessee. More recently, Battese and Coelli (1988) presented a generalization of this method for a given panel data of the Australian dairy farms, which will be discussed later.

3.2.5. Frontier Systems

The earlier applications of the frontier model have been used to estimate production frontiers primarily to measure technical inefficiency. In addition, one may be interested in measuring allocative inefficiency, that is, whether a firm is producing off its least cost expansion path.

The stochastic production frontier model has been extended by Schmidt and Lovell (1979) to allow measurement of average technical inefficiency for the population and allocative inefficiency for individual firm. The system of equations to be estimated are the production function as in Aigner et al.(1977) and factor share (proportion) equations derived from the first-order conditions for cost minimization. The behavioral assumption they used is cost minimization given a desired level of output, i.e., treating output as exogenous and inputs as endogenous. Let us briefly review the model of Schmidt and Lovell (1979) by first rewriting the Cobb-Douglas production function of Aigner et al. (1977) as

$$\ln y = a_0 + \Sigma\, a_i \ln x_i + v - u \tag{3.26}$$

where the condition $u \geq 0$ permits production to occur beneath the stochastic production frontier. They assume that the first order conditions for cost minimization are not satisfied, by writing

$$\ln(x_i / x_n) = \ln(a_i w_n / a_n w_i) + e_i \tag{3.27}$$

where e_i is symmetrically distributed, multivariate normal with zero mean.

This condition permits production to occur off the least cost expansion path. The combination of technical and allocative inefficiency yields a stochastic cost frontier of the form

$$\ln(w'x) = b_0 + 1/r \ln y + \Sigma_i b_i \ln w_i - 1/r(v-u) + E \tag{3.28}$$

where $b_i = a_i/r$ and $r = \Sigma_i a_i$. Actual cost exceeds the stochastic cost frontier for two reasons (i) due to technical inefficiency by an amount $(1/r)u \geq 0$, and (ii) due to allocative inefficiency by an amount $E \geq 0$, where E is well-specified function of the e_i.

The parameters of the system equation (3.26) and (3.27) were estimated from cross-sectional data for a sample of US steam-electric plants by using MLE under three different assumptions. Firstly, firms were assumed to be allocatively efficient, but technically inefficient. Secondly, firms were assumed to be both allocatively and technically inefficient but without any systematic tendency to over or under utilize any input. Thirdly, firms may be both technically and allocatively inefficient and may systematically tend to over or under utilize any input relative to any other input. In this model they were able to compute the mean technical inefficiency over the sample [E(u)], the individual allocative inefficiency (e_i), the cost of technical inefficiency [(1/r)E(u)], and the cost of allocative inefficiency (E).

Schmidt and Lovell (1980) extended this model in two directions. In the first place, they replaced the assumption that e_i has mean zero by the assumption that it has mean M, to permit a test of the hypothesis that allocative inefficiency is symmetric rather than random. In the second place, they relaxed the assumption that technical and allocative inefficiency are independent by permitting correlation between u_i and e_i. This permits a test of the hypothesis that firms that are relatively technically efficient are also relatively allocatively efficient. It should be pointed out, however, that the model works with a fairly restrictive functional form (Cobb-Douglas), and it requires data on both input prices and input quantities.

A system consisting of a deterministic translog cost frontier, a type of flexible functional form, and the associated factor share equations has been estimated by Greene (1980). The major weakness of the model is the difficulty in providing an explicit solution for the associated production function, or vise versa, which makes it impossible to see the relationship between inefficiency in one function relative to the other function.

It is well-known that either the production, cost or profit function uniquely define the technology. Which one is to be used depends on the behavioral assumption of the firms and/or data availability. The behavioral assumption underlying direct estimation of the cost function is cost minimization with output exogenous, which is usually related to the case of the regulated firm. This approach requires data on output quantity and input prices but not input quantities. The direct estimation of the profit function, which requires data on input and output prices, assumes that firms are profit maximizers. Cost and profit frontiers, like production frontiers, can be either deterministic or stochastic. The cost frontier yields information on the extra cost, while the profit frontier provides information on the forgone profit due to technical and allocative inefficiency. Separation of these two type of inefficiency is not possible without additional assumptions.

3.3. Dual Approach: Profit, Demand and Supply Function

One objective of is this study to derive the supply and input demand functions of the rice farms. Product supply and factor demand equations consistent with a firm's optimizing behavior can be obtained by two different but equivalent approaches. One approach, referred to as the primal approach, is to explicitly solve an optimization problem. Another approach, called the dual approach, allows one to obtain product supply and factor demand equations by partial differentiation of the objective function, either profit maximization or cost minimization. Applications of the dual approach begin with specification of a functional form for the profit or cost function, as opposed to the applications of the primal approach which begin with a production function specification.

Although duality theory does not offer any particular profound insights into production economic theory, it offers a more convenient way to obtain supply and demand equations than the primal approach. The dual approach is also useful in generating a more flexible functional specification for a consistent set of supply and demand equations for econometric estimation. Two principal advantages of dual approach are given by Diewert (1974). First, it enables us to derive systems of demand equations which are consistent with maximizing or minimizing behavior of an economic agent, simply by differentiating a profit (cost) function, as opposed to explicitly solving a constrained maximization or minimization problem, which is sometimes difficult and explicitly unsolvable in the case of more flexible functional forms. Most qualitative results of production theory follow from properties of the dual functions, without restrictive assumptions on the divisibility of commodities and convexity and smoothness of production possibilities. The second principal advantage is that it enables us to easily derive the "comparative static" theorems originally deduced from maximizing behavior.

Another obvious advantage is that profit, supply and the derived demand functions are explicitly written as functions of variables that are normally considered to be determined independently of a firm's behavior. Therefore, by estimating these functions directly, the problem of simultaneous equation bias can be avoided. Yotopoulos and Lau (1973; 1979) and Lau and Yotopoulos (1974) have explored the advantages of the dual approach by developing the so-called normalized restricted profit function using a Cobb-Douglas functional form, and implementing the model several empirical studies (Lau, Lin and Yotopoulos, 1979; Lau, Myers, and Chou, 1979). Sidhu (1974) used the Lau and Yotopoulos model for assessing relative economic efficiency in wheat production in the Indian Punjab. This model was also used by Sugianto (1982) and Kasryno (1985) to evaluate the relative economic efficiency of the irrigated rice farms in West Java, Indonesia. Other empirical studies using the Lau-Yotopoulos model can be found in Somel (1979), Kuroda (1979), and Tamin (1979). The duality between the profit and the production function, following Yotopoulos and Lau (1979), can be briefly outlined below.

3.3.1. The Case of Cobb-Douglas Production Function

Consider a Cobb-Douglas type of production function of the i^{th} firm as

$$Y_i = a_{oi} \Pi_k X_{ik}{}^{ak} \Pi_h Z_{ih}{}^{bh} \qquad (3.29)$$

where X_{ik}'s are the quantities of the variable inputs (k=1,...K) and the Z_{ih}'s are the quantities of the fixed inputs (h=1,...H), a_k is production elasticity of the k^{th} variable input, b_h is production elasticity of the h^{th} fixed input, while a_{oi} represent the level of technical efficiency of the i_{th} firm. It is assumed that the production function is in the stage of decreasing returns in variable inputs, in order to guarantee that maximum profit exists, that is $r = \Sigma_k a_k < 1$. Let W_k denotes the price of k^{th} variable input, and P denotes the price of output. The normalized restricted profit function, that is profit over variable cost normalized by price of output, corresponding to the above production function is

$$\pi_i = Y_i - \Sigma_k c_{ik} X_{ik} \tag{3.30}$$

where $c_k = W_k/P$ is the normalized price of the k^{th} variable input. Hoch (1962) and Yotopoulos and Lau (1979) incorporated the possibility of an allocatively inefficient firm (one that is unable to perfectly maximize profit) by introducing a non-unit factor of proportionality (d_{ik}) in the first order condition for profit maximization. The profit maximizing condition in this circumstance can be stated as

$$X_{ik} = a_k Y_i / c_{ik} d_{ik} \tag{3.31}$$

where $d_{ik} = 1$ for perfect profit maximization, d_{ik} is less than or greater than one when profit maximization is not perfect. The output supply function (3.32) can be derived by substituting equation (3.31) into equation (3.30) as

$$Y_i = a_{oi}^{1/(1-r)} (\Pi_k d_{ik}^{-ak/(1-r)})(\Pi_k a_k^{ak/(1-r)}) \\ (\Pi_k c_{ik}^{-ak/(1-r)}) (\Pi_h Z_{ih}^{bh/(1-r)}) \tag{3.32}$$

We can then derive the actual normalized profit function (3.33) for a i^{th} firm simply by substituting back equation (3.31) and (3.32) into profit equation (3.30), as follows:

$$\pi_i = a_{oi}^{1/(1-r)} \ (1- \Sigma_k a_k/d_{ik}) \ (\Pi_k d_{ik}^{-ak/(1-r)}) \qquad (3.33)$$
$$(\Pi_k a_k^{ak/(1-r)}) \ (\Pi_k c_{ik}^{-ak/(1-r)})$$
$$(\Pi_h Z_{ih}^{bh/(1-r)})$$

Simplifying equation (3.33) and then taking natural logarithms we get

$$\ln \pi_i = \ln \alpha_{oi} + \Sigma_k \alpha_k \ln c_{ik} + \Sigma_h \beta_h \ln Z_{ih} \qquad (3.34)$$

where:

$$\ln \alpha_{oi} = (1-r)^{-1} \ln a_{oi} + \ln(1 - \Sigma_k a_k/d_{ik})$$
$$- \Sigma_k a_k(1-r)^{-1} \ln d_{ik} + \Sigma_k a_k(1-r)^{-1} \ln a_k$$
$$\alpha_k = -a_k(1-r)^{-1}$$
$$\beta_h = b_h(1-r)^{-1}$$

so that the actual normalized restricted profit function of two or more farms differ only by a multiplicative constant α_{oi}. The i^{th} farm is said to be relatively more efficient than the j^{th} farm if π_i is greater than π_j. In the present Cobb-Douglas case, this implies $\alpha_{oi} > \alpha_{oj}$, which is also sufficient for the i^{th} farm to be globally (for all normalized prices and fixed inputs) relatively more efficient than j^{th} farm.

Similarly by direct computation the demand function for l^{th} variable input is given by

$$X_{il} = A_i^{1/(1-r)} \; (a_l \; / \; d_{il} \; c_{il}) \; (\Pi_k \; d_{ik}^{-aj/(1-r)} \;)$$
$$(\Pi_k \; a_k^{ak/(1-r)} \;) \; (\Pi_k \; c_{ik}^{-ak/(1-r)} \;)$$
$$(\Pi_h \; Z_{ih}^{bh/(1-r)} \;) \qquad (3.35)$$

where k, l = 1,2.....K. From equations (3.33) and (3.35), we can derive the ratio of l^{th} variable cost relative to profit, hereafter referred to as factor share function, as

$$c_{il} \; X_{il} \; /\pi_i = (a_l \; /d_{il} \;)/(1 \; - \; \Sigma_k \; a_k \; /d_{ik} \;) \qquad (3.36)$$

so that the ratio of expenditure on the l^{th} input to the actual normalized profit function is a constant. Moreover, this constant depends only on the vector of price efficiency parameter d_{ik} and the elasticities of production of the variable inputs. Equation (3.36) can be rewritten as

$$-c_{il} \; X_{il} \; /\pi_i = -(a_j \; /d_{il} \;)/(1 \; - \; \Sigma_k \; a_k \; /d_{ik} \;) = \alpha_{il}^* \qquad (3.37)$$

Equations (3.34) and (3.37) are the system equations from which Lau and Yotopoulos estimate the parameters. Several hypotheses related to relative efficiency and returns to scale can be constructed from these equations. First, two farms are equally price (in)efficient (d_i=d_j) if and only if $\alpha_{ik}^* = \alpha_{jk}^*$. Second, a farm is price efficient (d_i=1) if and only if $\alpha_{ik}^* = \alpha_k^*$. Third, two farms are of equal relative economic efficiency if and only if $\ln\alpha_{oi}^*=\ln\alpha_{oj}$. Fourth, two farms are equal in technical efficiency and price efficiency if and only if $\ln\alpha_{oi}=\ln\alpha_{oj}$ and $\alpha_{ik}^* = \alpha_{jk}^*$.

The next steps are to estimate the actual derived demand functions for variable inputs and the output supply function. Note that the actual profit function equation (3.34) can be rewritten as

$$\ln\pi_i = \ln\alpha_{oi} + \Sigma_k \alpha_k \ln W_k - (\Sigma_k \alpha_k) \ln P + \Sigma_h \beta_h \ln Z_h \tag{3.38}$$

Substituting equation (3.38) into equation (3.37) and then solving for $\ln X_{il}$, that is demand for l^{th} input, we get

$$\begin{aligned}\ln X_{il} = [\ln (-\alpha_{il}^*) + \ln\alpha_{oi}] + (\alpha_l - 1)\ln W_{il} + \Sigma_{k=l} \alpha_k \ln W_{ik} \\ + (1 - r^*) \ln P_i + \Sigma_h \beta_h \ln Z_{ih}\end{aligned} \tag{3.39}$$

where $r^* = \Sigma_k \alpha_k$, and $-\alpha_{il}$ is the coefficient of the l^{th} factor share function of the i^{th} farm as in equation (3.37).

By similar substitution process we can derive the output supply function with the final form as follows

$$\begin{aligned}\ln Y_i = [\ln(1 - \Sigma_k \alpha_k/d_{ik}) + \ln\alpha_{oi}] + \Sigma_k \alpha_k \ln W_{ik} \\ - r^* \ln P_i + \Sigma_h \beta_h \ln Z_{ih}\end{aligned} \tag{3.40}$$

The own- and cross-price elasticities of output supply and variable input demand can be obtained from equation (3.39) and (3.40) respectively. In addition, the elasticities of output supply and variable input demand with respect to the quantity of fixed input can also be obtained from these two equations.

3.3.2. The Case of Translog Profit Function

The development of the translog profit function as a more flexible functional form permits applications of duality theory for more disaggregated analysis of the production structure than is possible with the Cobb-Douglas functional form (Christensen, Jorgensen and Lau, 1976; Sidhu and Baanante, 1981). The main advantage of this functional form is that it allows the exogenous variables to produce different impacts across input demand functions. In the case of the Cobb-Douglas function, due to the well-known property of constant unitary elasticity of substitution among all input pairs, the impact across variable input demand functions of a given change in any of the exogenous variables is symmetric. Another disadvantage of the Cobb-Douglas function is that it fixes a priori the own-price elasticity of input demand to values greater than one, which is very unrealistic. The generalization of the normalized restricted translog profit function for a single output is given by :

$$\begin{aligned} \ln \pi_i = {} & \alpha_{oi} + \Sigma_k \alpha_k \ln c_{ik} + 1/2\, \Sigma_k \Sigma_l \tau_{kl} \ln c_{ik} \ln c_{il} \\ & + \Sigma_k \Sigma_h \delta_{kh} \ln c_{ik} \ln Z_{ih} + \Sigma_h \beta_h \ln Z_{ih} \\ & + 1/2\, \Sigma_h \Sigma_g \Phi_{hg} \ln Z_{ih} \ln Z_{ig} \end{aligned} \tag{3.41}$$

where $\tau_{kl} = \tau_{lk}$ (symmetry) for all k, l, and the function is homogenous of degree one in prices of all variable inputs and output. Differentiating the above profit function with respect to the normalized price of variable inputs gives a system of equations of variable input-profit ratios (factor share) or a system of variable input demand equations as

$$S_{ik} = - (c_{ik} X_{ik}) / \pi_i$$
$$= \alpha_k + \Sigma_l \tau_{kl} \ln c_{il} + \Sigma_h \delta_{kh} \ln Z_{ih} \tag{3.42}$$

Ideally, profits and variable inputs are determined simultaneously from equation (3.41) and (3.42). Several statistical tests may be done. The first statistical test is for the validity of the symmetry and parametric constraints across profit and S_j equations, or we may simply impose a symmetry restriction. The second statistical test is performed to test for the Cobb-Douglas hypothesis. For the profit function to be Cobb-Douglas, coefficients of all second order terms of the translog profit function should be zero. If the hypothesis is rejected, the translog representation is more suitable than Cobb-Douglas representation, or vice versa.

The demand equation which is derived from equation (3.42) can be written as

$$X_k = \pi/W_k \, [- \partial \ln\pi/\partial \ln W_k \,] \tag{3.43}$$

or in the logarithmic form becomes

$$\ln X_k = \ln\pi - \ln W_k + \ln[- \partial \ln\pi/\partial \ln W_k \,] \tag{3.44}$$

where ∂ is a symbol of partial derivative.

Given equation (3.44) we can derive (i) the own-price elasticity of input demand for k^{th} variable input (E_{kk}), (ii) the cross-price elasticity of demand for k^{th} variable input with respect to the price of l^{th} input (E_{kl}), (iii) the elasticity of demand for the k^{th} variable input with respect to output price (E_{ky}), and (iv) the elasticity of demand for the k^{th} variable input with respect to fixed input Z_h (E_{kzh}). The derivation of these elasticities can be found in Sidhu and Baanante (1981). The following is the final result:

$$E_{kk} = -\underline{S}_k - 1 - \tau_{kk} / \underline{S}_k \tag{3.45}$$

$$E_{kl} = -\underline{S}_l - \tau_{kl} / \underline{S}_k \tag{3.46}$$

$$E_{ky} = \Sigma_k \underline{S}_k + 1 + \Sigma_l (\tau_{kl} / \underline{S}_k) \tag{3.47}$$

$$E_{kzh} = \Sigma_k \delta_{kh} \ln\underline{W}_k + \beta_h - \delta_{kh} / \underline{S}_k \tag{3.48}$$

where $\underline{S}_k$ is a simple average of S_k and $\underline{W}_k$ is the simple average price of the k_{th} variable input.

The supply function can be derived by substituting equation (3.43) into equation (3.30) and solving for Y as

$$Y = \pi \left[1 - \Sigma_k \partial\ln\pi/\partial\ln W_k \right] \tag{3.49}$$

or in logarithmic form becomes

$$\ln Y = \ln\pi + \ln[1 - \Sigma_k \partial\ln\pi/\partial\ln W_k] \tag{3.50}$$

The own-price elasticity of supply (E_{yy}), the elasticities of supply with respect to price of k_{th} variable input (E_{yk}), and the elasticity of output supply with respect to fixed input Z_h (E_{yzh}) are respectively computed from:

$$E_{yy} = \Sigma_k S_k + \Sigma_k \Sigma_l \tau_{kl} /(1 + \Sigma_l S_l) \tag{3.51}$$

$$E_{yk} = - S_k - \Sigma_l \tau_{lk} /(1 + \Sigma_l S_l) \tag{3.52}$$

$$E_{yzh} = \Sigma_k \delta_{kh} \ln W_k + \beta_h - \Sigma_k \delta_{kh} /(1 + \Sigma_l S_l) \tag{3.53}$$

3.4. Stochastic Profit Frontier and Profit Efficiency

The restricted profit function of Yotopoulos and Lau (1979) implies that the underlying production function is an "average" function which is not consistent with the neoclassical notion of a firm-specific production function. Furthermore, the Yotopoulos and Lau's profit function approach can be used to analyze productivity differences between group of firms only in relative terms, assuming equal efficiencies within each group. Individual specific efficiency, however, cannot be quantified. Kalirajan (1985), following the frontier production model of Aigner, Lovell and Schmidt (1977), developed a stochastic restricted profit frontier and implemented the model on micro-level data for Indian farm production.

The derivation of the stochastic profit frontier is straightforward and follows directly the steps of the derivation of the non-frontier profit function outlined above. The only difference is that the error terms of the production function as formulated by Aigner et al. (1977) are taken into account in the derivation process to keep track the primal-dual error relationship. Once again, for convenience and for theoretical purpose, we use a Cobb-Douglas type of function since it is not possible to assess dual-primal relationship by using more flexible functional, such as translog.

Following Kalirajan (1985), consider the Cobb-Douglas production function as formulated by Aigner, Lovell and Schmidt (1977)

$$Y_i = a_o \Pi_k X_{ik}^{ak} \Pi_h Z_{ih}^{bh} e^{-ui+vi} \tag{3.54}$$

where Y_i, X_{ik} and Z_{ih} have been defined in equation (3.29), while the error components u and v are defined in equation (3.24). Recall that v_i captures random variation in input due to factors beyond the control of the i^{th} firm, such as weather and luck, and is assumed to be distributed as $N(0,\sigma_v^2)$, while u_i is non-negative disturbance capturing randomness under the control of the i^{th} firm, that is technical inefficiency.

Let assume that firm is technically inefficient but allocatively efficient. Recall the normalized restricted profit equation (3.30). For simplicity let us omit the i subscript. The profit maximizing condition, assuming firm is maximizing anticipated (expected) profit as in Hoch (1962), is

$$X_k = (a_k/c_k)Y \tag{3.55}$$

Substituting (3.55) into equation (3.54) yields:

$$Y = a_o^{1/(1-r)} \Pi_k a_k^{ak/(1-r)} \Pi_k c_k^{-ak/(1-r)} \Pi_h Z_h^{bh/(1-r)} e^{(u+v)/(1-r)} \tag{3.56}$$

where $r = \Sigma_k a_k < 1$. Substituting equation (3.55) and (3.56) into equation

(3.30) yields the normalized restricted stochastic profit frontier as:

$$\pi = a_0^{1/(1-r)}\ (1-r)\ \Pi_k\ a_k^{ak/(1-r)}\ \Pi_k\ c_k^{-ak/(1-r)}\ \Pi_h\ Z_h^{bh/(1-r)}\ e^{(u+v)/(1-r)} \tag{3.57}$$

Note that the profit equation (3.57) is bounded by the stochastic profit frontier as:

$$\pi = a_0^{1/(1-r)}\ (1-r)\ \Pi_k\ a_k^{ak/(1-r)}\ \Pi_k\ c_k^{-ak/(1-r)}\ \Pi_h\ Z_h^{bh/(1-r)}\ e^{u/(1-r)} \tag{3.58}$$

This represents the maximum possible profit for a given normalized price and amount of fixed input. The profit frontier is stochastic, as is the production frontier, because of the randomness of the v which reflects any shocks beyond the control of the firm. The term u/(1-r) represents the percent by which actual profit is less than the profit frontier. In other words it measures the profit forgone of producing below the production frontier due to technical inefficiency.

Now we allow for the possibility that the firm may also be allocatively inefficient. Allocative inefficiency is modelled by permitting the profit maximizing (cost minimizing) condition to fail to hold exactly. Let us assume further that a firm makes systematic errors in seeking to equate the marginal value with marginal factor cost for any particular input. These assumptions yield the first-order profit maximizing conditions as follows:

$$X_k = (a_k\ Y / c_k)\ e^{wk} \tag{3.59}$$

where $w = (w_1, \ldots\ldots w_K)$ has a multivariate normal distribution with mean $\bar{W}$ and variance-covariance matrix Σ. Substituting equation (3.59) into the production frontier equation and simplifying, gives:

$$Y = a_0^{1/(1-r)} \Pi_k a_k^{ak/(1-r)} \Pi_k c_k^{-ak/(1-r)} \Pi_h z_h^{bh/(1-r)} e^{(u+v)/(1-r)} e^{-\Sigma k\ (ak\ wk)/(1-r)} \tag{3.60}$$

Substituting equation (3.59) and (3.60) into equation (3.30), gives

$$\pi = a_0^{1/(1-r)} (1 - \Sigma_k a_k e^{-wk}) \Pi_k a_k^{ak/(1-r)} \Pi_k c_k^{-ak/(1-r)} \Pi_h Z_h^{bh/(1-r)} e^{(u+v)/(1-r)} e^{-\Sigma k\ (ak\ wk)/(1-r)} \tag{3.61}$$

This can be simplified as:

$$\pi = \alpha_0 \Pi_k c_k^{\alpha k} \Pi_h Z_h^{\beta h} e^{u^*+v^*+s^*} \tag{3.62}$$

where:

$$\alpha_0 = a_0^{1/(1-r)} (1 - \Sigma_k a_k e^{-wk}) \Pi_k a_k^{ak/(1-r)}$$

$$\alpha_k = - a_k / (1-r)$$

$$\beta_h = b_h / (1-r)$$

$$u^* = u/(1-r)$$

$$v^* = v/(1-r)$$

$$s^* = - \Sigma_k (a_k w_k)/(1-r)$$

Taking logarithms on both sides of equation (3.62), yields the following stochastic profit frontier:

$$\ln\pi = \ln\alpha_o + \Sigma_k\, \alpha_k \ln c_k + \Sigma_h\, \beta_h \ln Z_h + u^* + s^* + v^* \tag{3.63}$$

Kalirajan (1985) estimated equation (3.63) by using the method of maximum likelihood, assuming the density functions for u*, v*, and s* as specified above.

If we are not interested in separate estimates of u* and s*, we can simply combine them together and define this combined error component as an economic or profit inefficiency measure. The model can then be viewed as a generalization of stochastic production function previously described. This approach was used by Ali and Flinn (1989) for measuring farm-level profit efficiency among the Basmati rice producers (Pakistan Punjab) using cross-sectional data.

3.5. Panel Data and Stochastic Frontiers

The estimation of individual technical inefficiency from a set of panel data was done by Hoch (1955; 1962). He, however, used an "average" (non-frontier) function rather than frontier function. Hoch assumed that firms maximize anticipated profit, and then estimated the production parameters using covariance analysis.

There are great potential advantages for modifying existing frontier models to allow the use of panel data. Schmidt and Sickles (1984) pointed out three difficulties in applying stochastic production frontier models reviewed so far using cross section data. First, one can estimate technical inefficiency of each firm but not consistently. Second, separation of inefficiency measures from statistical noise depends on specific assumptions about the distribution of technical inefficiency.

Third, the assumption that inefficiency is independent of regressors is not valid if a firm knows its level of technical inefficiency. These difficulties will analogously be found in using cross-section stochastic profit frontiers.

With the availability of panel data these problems can be avoided. First, if there are T observations on each firm, then the technical inefficiency of a particular firm can be estimated consistently as T tends to infinity. Second, any distribution of technical inefficiency need not be assumed if these are treated as firm-specific effects. Third, no assumption is needed regarding the independence of technical inefficiency and the regressors.

This section is drawn heavily from Schmidt and Sickles (1984) article, with some modification in notation. Consider a production function as:

$$y_{it} = a_0 + x_{it}\, a + v_{it} - u_i \tag{3.64}$$

Here, $i = 1,2...N$ indexes firms and $t = 1,2...T$ indexes time period. The value y_{it} is output of the i^{th} farm at time t, whereas x_{it} is a vector of K inputs. The v_{it} are assumed uncorrelated with regressors and distributed iid $N(0,\sigma_v^2)$. The u_i represent technical inefficiency and $u_i \geq 0$ for all i. It is also assumed that u_i is iid with mean U and variance σ_u^2 and is independent of the v_{it}. A particular distribution for u_i may or may not be assumed. Furthermore, the u_i may or may not be assumed to be correlated with regressors.

For T=1 (a single cross section) the model is the stochastic frontier of Aigner, Lovell and Schmidt (1977). For T > 1, it is a straightforward generalization of that model, and it fits the usual framework in the panel-data literature with individual effects but no time effects, as previously discussed in section 2.1. The only difference from the standard panel data model is that individual effects are one-sided.

The equation (3.64) can be rewritten in two ways. First, let $E[u_i] = \underline{u} > 0$, and define

$$a_0^* = a_0 - \underline{u} \quad \text{and} \quad u_i^* = u_i - \underline{u}$$

so that u_i^* are iid with mean 0. Equation (3.64) then can be rewritten as

$$Y_{it} = a_0^* + X_{it}'a + v_{it} - u_i^* \tag{3.65}$$

with the error terms v_{it} and u_i^* have zero mean. Most of the results of panel data literature can be applied directly, except those that hinge on normality.

Secondly, define

$$a_{0i} = a_0 - \underline{u} = a_0^* - u_i^*$$

and then rewrite the model into

$$Y_{it} = a_{0i} + X_{it}'a + v_{it} \tag{3.66}$$

This is exactly a variable intercept model as equation (3.2)

<u>Dummy Variable Estimator (Fixed Effect)</u>

As mentioned in section 3.1.1, this estimator treats the u_i as fixed, that is, it estimates a separate intercept for every individual firm as in (3.66). This can be done by suppressing the constant term and adding a dummy variable for each of the N farms or, equivalently, by keeping the constant term and adding (N-1) dummies. Another equivalent procedure is to apply the within transformation, that is, to apply OLS after transforming the data in terms of deviations from the farm means.

The advantage of the within estimator is that its consistency does not hinge on uncorrelatedness of the regressors and the effects. It also does not depend on the distribution of the effects, since in treating them as fixed it simply proceeds conditionally from whatever their realizations are. The estimates of a is consistent as either N or T tends to infinity. Consistency of the individual estimated intercept requires $T \to \infty$.

A considerable disadvantage of the within estimator is that it is impossible to include in the specification the time invariant regressors even though they vary across farms. In this case the estimated individual effects will include the effects of all variables that are fixed within the sample at the farm level, possibly including some that are not in any sense a representation of inefficiency (Schmidt and Sickles, 1984).

In the case of the frontier function, if N is large, we can use the fact that $u_i \geq 0$ to appropriately normalize the individual effects (u_i) and the overall constant (a_0). If N estimated intercepts are $\hat{a}_{01}$, $\hat{a}_{02}, \ldots .\hat{a}_{0N}$, simply define

$$\hat{a}_0 = \max\,(\hat{a}_{0i}) \tag{3.67a}$$

$$\hat{u}_i = \hat{a}_0 - \hat{a}_{0i} \tag{3.67b}$$

This definition amounts to counting the most efficient firm in the sample as 100% efficient. The estimates $\hat{a}_0$ and $\hat{u}_i$ are consistent as N and T go to infinity.

<u>EGLS Estimator (Random Effects)</u>

With σ_v^2 and σ_u^2 known, the GLS estimator of a_0* and a of equation (3.65) is consistent as either N or T approaches infinity. It is more efficient than the within estimator in the case of $N \rightarrow \infty$ and T fixed, but this difference in efficiencies disappears as $T \rightarrow \infty$. When σ_v^2 and σ_u^2 are not known, their consistent estimates need to be estimated. Consistent estimation of σ_u^2 requires $N \rightarrow \infty$. Thus the strongest case for GLS is when N is large and T is small. If the opposite is true the GLS is useless, unless σ_u^2 were known <u>a priori</u>.

Given estimates of $\hat{a}$, we can recover estimates of the individual firm intercepts ($\hat{a}_{0i}$) from the residuals, that is, the mean (over time) of the residuals of each individual firms.

$$\hat{a}_{0i} = 1/T \; \Sigma_t \; \hat{e}_{it} \tag{3.68}$$

These estimates are consistent as $T \rightarrow \infty$, provided that estimates of a are consistent. Note that $\hat{a}_{0i}$ can be decomposed into $\hat{a}_0$ and u_i, for which consistency requires $N \rightarrow \infty$ and consistency of the $\hat{a}_{0i}$. Another way to estimate the individual effects (inefficiency) is by using Battese and Coelli (1986) method, which is actually a generalization of the method suggested by Jondrow et.al (1982) as described in equation (3.25). The Battese and Coelli method is presented in a slightly different notation as follows:

$$Q_i = 1 - \frac{[\ 1 - F(\sigma^* - m_i/\sigma^*)\ ]}{[\ 1 - F(-m_i/\sigma^*)\ ]} \exp(-m_i + \sigma^*/2) \tag{3.69}$$

where

$$\sigma^* = \sigma_u^2\ \sigma_v^2\ (\sigma_v^2 + T\sigma_u^2)^{-1}$$
$$m_i = -(\sigma_u^2\ \underline{e}_i)(\sigma_u^2 + \sigma_v^2/T)^{-1}$$
$$\underline{e}_i = \hat{a}_{0i} - \underline{u}$$

Note that $\underline{u}$ and $\hat{a}_{0i}$ have been described in equation (3.24a) and (3.68), respectively, while F is a symbol for standard normal cumulative distribution function (cdf).

The important advantage of GLS estimator relative to within estimator in the present context is not efficiency, but rather the ability to include the time invariant regressors. In cases where time-invariant regressors are relevant, this is important so that their effects do not contaminate measured efficiency.

The problem with Fixed Effect (FE) model is that if there are any time invariant variables that are excluded, the firm dummies will reflect this influence. This would make inefficiency comparisons difficult unless the excluded time-invariant variables affect all firms equally. Since this is not always the case, inefficiency measures relative to the best firm (which has to be assumed 100% efficient in FE model) might give misleading results. Thus, even though FE models have the advantage of allowing correlation among inefficiency and the regressors and no distributional assumption on inefficiency is required, the results should be interpreted carefully. Khumbakar (1986), in his study of the U.S. Class 1 railroads, found that the estimates of inefficiency in the FE models are much bigger than those of random effect (RE) models. On the other hand, all the production function parameters in the FE model are much lower than those in the RE model.

The choice between these two has nothing to do with the frontier model as such. The only problem with the FE framework in the context of a production or cost (profit) frontier is that the firm-specific effects pick up the effect of variables that differ across firms but are invariant over time. These effects are not in any sense a representation of inefficiency. This might be one of the reasons why estimated inefficiencies in the FE models are much greater than in the RE models.

Given the potential differences in results, both in magnitude of inefficiency and efficiency ranking of the firms, one may think to conduct a specification test, to examine whether the random effect models is correct, i.e., the Hausman (1978) or the Mundlak (1978) test, as in equation (3.20) and (3.21) respectively. Since inputs might be correlated with technical inefficiency, there is a strong justification for performing this test when dealing with the estimation of the production function by single equation methods. But for a profit (cost) function, inefficiencies can be assumed with greater confidence to be uncorrelated with input prices.

3.6. Adoption of New Technology: A Multinomial Logit Model.

Another objective of this study is to determine factors affecting farmer decisions in choosing rice variety. This objective is motivated by the fact that there were many farmers in the sample still growing TV, despite the fact that HYVs have long been introduced by the government.

Applications of probability models to evaluate varietal adoption in the West Java rice farming have been done by Hutabarat (1986) using a probit model and Gunawan (1988) using a logit model. This study instead will use a multinomial logit model. An example of an empirical study using a multinomial logit model is found in Schmidt and Strauss (1975), which analyzed patterns of employment in the US labor market using race, sex, educational attainment and labor market experience as explanatory variables.

The derivation of the multinomial logit model can be found in, among others, Judge et al. (1985) and Fomby et al. (1984). The multinomial logit model is based on the assumption that the error terms are independently and identically distributed with Wibull density functions. Let there be N possible choices, with probabilities P_1, $P_1, \ldots P_N$. The multinomial logit model, omitting individual (observation) subscript, can then be written as

$$\ln(P_j/P_1) = X\,\beta_j \qquad (3.70)$$

where j=2,....N, X is a 1xK vector of explanatory variables, and β_j is a Kx1 vector of unknown parameters. The N-1 equation in (3.70) plus the requirement that the probabilities for each individual sum to one, determine the probabilities uniquely. The probability of each choice is explicitly as follows:

$$P_1 = \frac{1}{1 + \Sigma_j \exp(X\beta_j)} \tag{3.71}$$

$$P_i = \frac{\exp(X\beta_i\ )}{1 + \Sigma_j \exp(X\beta_j)} \tag{3.72}$$

These probabilities are commonly evaluated at the mean value of the explanatory variables.

Given equation (3.71) and (3.72), one can derive response elasticities for any change in explanatory variables (appendix 3.1). This measure represents a percentage change in probability of particular event as a result of a one percent change in the value of any explanatory variable. This elasticity is evaluated at the mean value of explanatory variables.

3.7. Policy Evaluation: Rice Price Support and Fertilizer Subsidy

In general the evaluation of policy alternatives can be done by assessing their impact on the welfare of the producers and consumers and the government budget, using the world prices as a standard of reference to judge the opportunity costs of particular policies. Timmer (1986) argued that understanding the logic of the border prices (also referred to as parity prices) is the essential first step in addressing any further policy concerns about the implementation and impact of changes in domestic prices for food and agricultural commodities.

Evaluating domestic price policy relative to border prices starts with the supply and demand functions of the domestic market for a commodity.

The supply function reflects the initial stage of technology and productivity of the commodity being analyzed, including the cost of inputs and alternative commodities that farmers might grow. The demand function represents the tastes of consumers, the level and distribution of incomes, and the prices of alternative commodities. These supply and demand curves reflect only part of the reaction to a change in the price of the commodity in question, which commonly is referred to as "partial equilibrium" models. When the commodity is important to the entire economy, a staple food such as rice, the partial equilibrium models provide only an initial glimpse of the full adjustments likely to occur when the price changes (Timmer, 1986; Timmer, 1987). More complicated analytical techniques are necessary to understand the full effect of the price policy.

The simple supply and demand model may be used to explain basic price policy issues as well as to provide a base from which to identify the necessity for more complicated analysis. A price change for the main staple food, or significant price changes simultaneously for multiple commodities, are likely to cause multimarket spillover effects. Timmer (1986;1987) measures the "importance" of the commodity in one of the following four ways. First, the commodity is the chief wage good in the society and forms a significant share (20-50%) of the average consumer's budget. Second, the commodity is a major source of farm income. Changing the price alters farm incomes and hence farm expenditures on goods and services. Price changes also cause farmers to change input use and alter their cropping patterns and therefore affect national agricultural production. Third, the commodity is important in the country's international trade as an export or an import. Either way, changes in domestic prices are likely to alter trade volumes and hence the foreign exchange balance. Finally, the commodity is important to the government budget, either as a generator of revenue or as a significant drain because of large subsidies.

The standard partial equilibrium analysis using border prices as the measure of domestic opportunity cost can be used to assess the impact of price changes by measuring gains and losses in producer and consumer welfare, transfer to and from the government budget, changes in foreign exchange earnings and expenditures, and efficiency losses (deadweight losses). The partial equilibrium analysis assumes that there are no adjustments in the economy other than those being analyzed.

The most difficult situation of agricultural price policy analysis occurs when the commodity is important for all four reasons. This is a common situation in developing countries in which a primary food staple is grown domestically and imported or exported. Rice in Indonesia easily meets all these criteria. Timmer (1987) pointed out that analysis of such commodity extends beyond the boundaries of partial equilibrium models even if the political dimensions remain outside the formal analysis itself.

All markets are linked together by substitution possibilities in production and consumption. Timmer (1986;1987) argued that one approach to determine whether general equilibrium consequences are significant is to work from the simple to the complex, starting with a single-market analysis. When this first step is carried out carefully and thoughtfully, it provides clear directions about where to look for the most immediate impact on other markets. A policy intervention that lowers the rice price, for instance, will lead to a reduction in rice production that, in turn, will be accompanied by diminished used of inputs including labor and by some increased effort on other crops or activities. Immediately, at least three other markets, input market such as fertilizer, alternative output markets and rural labor market, are identified as having potentially significant links to the rice market which would adjust to a change in rice price.

Another approach is commonly referred to as a sector-wide model. Because price policy changes can lead to a complex combination of changes in incomes of producers and to shifts in use of regional or national resources, such as land, water and labor, a sector-wide model is required to trace the most important effects. Agricultural sector models have been used since the mid-1960s to check the consistency of agricultural development plans and to examine resource requirements of alternative cropping patterns (Timmer, 1987). Unlike single-market or multi-market equilibrium models, sector models contain detailed farm models as the basis for supply response and alternative crops in the face of changed prices.

World market prices, as a measure of domestic opportunity cost, should be used with caution due to the instability of world commodity markets. A domestic floor price announced in the beginning of planting season, for example, may well reflect the opportunity cost of imports at the time of the announcement but be too low or too high by the time of harvest. Instability in international prices is therefore a serious issue for the design of domestic price policy in the short run, whereas long-run structural changes in the world food system affect investment decisions about agricultural research, rural infrastructure, and sectoral priorities.

According to Timmer et al. (1983), agricultural and food price policies are commonly judged by their effects on the following four food policy objectives: (i) promoting economic efficiency and hence faster growth of income, (ii) distributing income more equally, (iii) guaranteeing adequate nutritional status for all people, and (iv) providing security of food supplies. Empirical analysis of a policy requires measurement of the size as well as the direction of its impact. In addition, the weights given to the objectives and the constraints, including international repercussions, determine the actual feasibility and efficacy of a price policy.

In evaluating output price support and input subsidy policies in the Philippine rice economy, Barker and Hayami (1976) used a simple demand-supply model combined with a benefit-cost analysis. They started the analysis by evaluating the programs of rice price support and fertilizer subsidy for achieving rice self-sufficiency as the main goal. Benefits and costs associated with these alternative programs and their income distribution effects are estimated and compared with the case of no price support or fertilizer subsidy. They concluded that a subsidy applied to modern input, such as fertilizer, that are being used below optimum level can be more beneficial than supporting the price of rice. Unfortunately, the Barker and Hayami approach requires large amounts of data.

Another empirical study in agricultural policy evaluation was done by Hayami, Bennagen and Barker (1977). Using rice economy in the Philippines as a case and benefit-cost analysis as the main tool of analysis, they evaluated and compared the irrigation investment and price incentive policies. They concluded that, in the long run, despite its large initial capital cost, irrigation investment imposes less financial burden on the government than the manipulation of product and input prices. In terms of the social benefit-cost ratio, the irrigation development is clearly more efficient than rice price support, but it becomes inferior to fertilizer subsidy if high discount rate is applied to a large-scale and high-cost irrigation project.

In this study, we attempt to evaluate rice price support and fertilizer subsidy policies in much simpler way. The main reason for not using benefit-cost analysis, as in Barker and Hayami (1976), is lack of data. We also do not intend to assess these policy options with those above four objectives specified by Timmer et al. (1983). We instead will focus on the impact of these policies on increasing total rice production as well as promoting rural employment. The evaluation is based on the estimated cross- and own-price elasticities of the rice supply and variable input demand, given the following information: (i) total quantity of subsidized fertilizer for rice production, (ii) total quantity of excess rice supply in the market purchased by the government, and (iii) total rice production, (iv) total labor used in the rice production, (v) the price of rough rice, and (vi) the price of fertilizer.

The main idea of the proposed evaluation procedure, which will be described in the next section, is based on a comparison between rice price support and fertilizer subsidy policies on the the government' costs in generating an additional kilogram of rough rice and promoting an additional unit of employment in the rural areas. The more desirable policy is the one which is less costly. Note, however, that this procedure only evaluates the impact of the policy on the government budget, and ignores the welfare impact on consumers and producers of rice.

IV. MODEL SELECTION AND ESTIMATION

The purpose of this chapter is to present the models, estimation methods and the data transformation. This chapter consists of six sections and is organized as follows. Section one and two present the model selection and estimation methods of the production and profit function approaches, respectively. Section three describes the model selection and estimation method of the system of equations consisting of the profit function and variable factor share equations. The specification of the multinomial logit model for varietal choices, along with the estimation method, is outlined in section four. Section five describes the procedure for evaluating the rice price support and fertilizer subsidy policies. Finally, section six describes the data transformation with regard to the variables used in the analysis.

4.1. Production function

Direct estimation of the production function gives consistent parameter estimates only when input can be treated as exogenous. The Hoch's (1962) argument of anticipated profit maximization and the Zellner et al. (1966) argument of expected profit maximization can be used to treat inputs as exogenous.

The main purpose of the direct estimation of the production function in this study, in addition to the estimation of production elasticities, is to measure individual technical inefficiency. One can use a non-frontier or an "average" function to estimate technical inefficiency but only under certain restrictive assumptions. The result of the inefficiency measure, however, cannot be called a pure measure of technical inefficiency since it also includes random variability. The frontier production function is designed to bridge the gap by introducing the error term to represent an (in)efficiency measure.

4.1.1. Model Selection and Functional Forms

The per farm (household) production function, using the Cobb-Douglas type and the more flexible transcendental logarithmic (translog) functional forms, will be estimated in this study. One of the objectives is to check whether or not the individual level of technical inefficiency is insensitive to the functional form used.

Cobb-Douglas Type Production Frontier

The total output per farm, measured in kilograms of rough rice, is the dependent variable, while the total quantity of seed, fertilizer, labor and farm size of the corresponding farm household, are the independent variables. By assuming that farmer is maximizing anticipated profit, all of the production inputs can be treated as exogenous variables, and therefore, the distinction of whether a particular input is variable or fixed is irrelevant.

In logarithmic form, the per farm Cobb-Douglas production function to be estimated is specified as follows:

$$\begin{aligned} \ln Y_{it} = {} & \ln a_0 + \Sigma_k a_k \ln X_{kit} + a_6 DP_{it} + a_7 DV1_{it} + a_8 DV2_{it} \\ & + a_9 DSS + a_{10} DSIZE + a_{11} DR1 + a_{12} DR2 \\ & + a_{13} DR3 + a_{14} DR4 + a_{15} DR5 + v_{it} - u_i \end{aligned} \tag{4.1}$$

where:

$i = 1,2,.....171$ subscript for individual observations

$t = 1,2,.....6$ subscript for time

$k = 1,2,.....5$ subscript for production inputs

v = the error component represents random noise, and is assumed to be distributed normally with zero mean and variance of σ_v^2.

u = the non-negative error component representing technical inefficiency.

lnY = lnKGOUT: total production in the form of rough rice in kilogram.

lnX1 = lnKGS: the amount of seed (kg)

lnX2 = lnKGN: the amount of urea (kg)

lnX3 = lnKGP: the amount of TSP (kg)

lnX4 = lnLAB: the amount of labor (hours)

lnX5 = lnHA: area planted with rice (ha)

DP: dummy variable of pesticide use, equals 1 if farmer uses pesticides and equals 0 otherwise

DV1: dummy HYV variety, equals 1 if HYV, zero otherwise

DV2: dummy of Mixed Varieties (MV), equals 1 if mixed varieties are used, zero otherwise.

Note: traditional variety (TV) is the control

DSS: dummy variable of season, equals 1 if wet season, zero otherwise

DSIZE: dummy variable of farm size, equals 1 if farm size greater than 0.5 ha, zero otherwise

DR1: dummy village, equals 1 if desa Lanjan kabupaten Indramayu, zero otherwise.

DR2: dummy village, equals 1 if desa Gunung Wangi kabupaten Majalengka, zero otherwise

DR3: dummy village, equals 1 if desa Malausma kabupaten Majalengka, zero otherwise

DR4: dummy village, equals 1 if desa Sukaambit kabupaten Sumedang, zero otherwise

DR5: dummy village, equals 1 if desa Ciwangi kabupaten Garut, zero otherwise.

Note: Wargabinangun (kabupaten Cirebon) is the control village

Translog Production Frontier

The translog is a flexible functional form based on the second order Taylor series approximation of any function. The Cobb-Douglas functional form is a very special type of the translog functional form in the case that all the coefficients of the second order terms are zero. Note that the translog specification only applies to the production inputs, not to the categorical (dummy) variables.

The specification of the per farm translog production function used in this analysis is as follows:

$$
\begin{aligned}
\ln Y_{it} = {} & \ln a_0 + \Sigma_k a_k \ln X_{kit} + 1/2\, \Sigma_k \Sigma_l a_{kl} \ln X_{kit} * \ln X_{lit} \\
& a_6 DP_{it} + a_7 DV1_{it} + a_8 DV2_{it} + a_9 DSS + a_{10} DSIZE \\
& a_{11} DR1 + a_{12} DR2 + a_{13} DR3 + a_{14} DR4 + \\
& a_{15} DR5 + v_{it} - u_i
\end{aligned} \tag{4.2}
$$

The variable definition is the same as that of Cobb-Douglas described above. The symmetry restriction is *a priori* imposed implying that the coefficient of (1/2) of the second order terms will occur only if k = l.

4.1.2. Estimation Methods

Two estimators, i.e.,. the within and EGLS estimators, are used in this study. In addition to these two estimators, the simple OLS estimator will also be presented for comparison purposes. As indicated in the previous chapter, it is possible and even more efficient to use MLE, since it can fully utilize the information of the distributional assumption of the error component, especially the one-sided error component representing inefficiency measure. However, due to the complicated nature of the latter (which sometimes offsets its potential gain of efficiency) there was no attempt to use this estimator in this study.

The within estimator is simply obtained by running OLS on the transformed data as described in equation (3.6) in chapter 3. To obtain the EGLS estimator, the steps described in chapter 3 section 3.1.2 are used. One way to decide whether to use fixed effects (FE) or random effects (RE) model is to test the null hypothesis that there is no correlation between the individual effects and the included explanatory variables against the alternative hypothesis that such correlation exists. For this purpose, we can use either Hausman test (1978) or an asymptotically equivalent test suggested by Mundlak (1978) as discussed in chapter 3. If the null hypothesis holds we use the random-effects model; otherwise we use the fixed-effect model.

The individual level of technical inefficiency is measured using Battese and Coelli (1986) method as described in equation 3.69 in chapter 3. The methods presented in section 3.5, specifically equation (3.67) for FE model and equation (3.68) for RE model, will also be employed for comparison purposes.

4.2. Profit Function

As pointed out in the previous chapter, the dual approach offers an easier way to obtain output supply and input demand equations compared to the primal approach. The dual approach is also useful in generating a more flexible functional specification for a consistent set of supply and demand equations for econometric estimation.

Unlike the case of production function presented previously, a distinction between fixed and variable inputs is relevant in this case, since it has an implication of whether or not the price of a particular input needs to be taken into account in the production decision process.

In this analysis, we make the following specification. To produce rice, each farmer must first decide how many hectares to plant. The farmer can then determine the amount of seed, fertilizer and labor to use for his land. Thus, the planning horizon for the farmer is a short-run period covering only one season of rice production. This planning and production process is assumed to be repeated for each planting season. In this case we can therefore treat hectareage of land (farm size) as fixed input, while seed, fertilizers and labor as variable inputs.

Farmers are assumed to maximize restricted profit, that is profit over variable costs, subject to a production function; thus, variable factor prices, quantities of fixed factors, and price of output are considered as exogenous, but not output. This is consistent with the Zellner, Kmenta and Dreze (1966) approach of maximizing expected profit, assuming that prices and quantities of fixed factors of production are exogenous variables (Kalirajan, 1985).

4.2.1. Model Selection and Functional Forms

The Cobb-Douglas and translog functional forms, as in the production function approach, will be used in this analysis, to determine if individual level of profit inefficiency is insensitive to the functional form. In this analysis, the translog specification only applies to the prices and fixed inputs, not to the categorical variables.

Cobb-Douglas type of Profit Frontier

In its notation, the specification of the Cobb-Douglas restricted profit function is the same as the production function. The difference is in the independent variables involved in the model. In the logarithmic form, the Cobb-Douglas restricted profit function to be estimated is

$$\begin{aligned} \ln\pi_{it} = {} & \ln a_0 + \Sigma_k a_k \ln C_{kit} + a_4 \ln Z + a_5 DP_{it} + a_6 DV1_{it} \\ & + a_7 DV2_{it} + a_8 DSS + a_9 DSIZE + a_{10} DR1 + a_{11} DR2 \\ & + a_{12} DR3 + a_{13} DR4 + a_{14} DR5 + v_{it} - u_i \qquad (4.3) \end{aligned}$$

where:

k = 1,2,3 is subscript for variable input prices.

v = the error component represents random noise, and is assumed to be distributed normally with zero mean and variance of σ_v^2.

u = the non-negative error component representing profit inefficiency.

$\ln\pi$ = ln LPRO: restricted profit, that is profit over variable cost, normalized by per kg price of rough rice

$\ln C_1$ = lnLPS: per kg price of seed normalized by per kg price of rice

$\ln C_2$ = lnLPF: per kg price of fertilizer normalized by per kg price of rice

$\ln C_3$ = lnLWG: per hour labor wage normalized by per kg price of rice

$\ln Z$ = LnHA: farm size, as a fixed factor, in hectare.

The definition of the remaining variables is the same as before.

Translog Profit Frontier

The specification of the translog profit function used in this analysis is as follows:

$$
\begin{aligned}
\ln\pi_{it} = {} & \ln a_0 + \Sigma_k\, a_k \ln C_{kit} + 1/2\, \Sigma_k\, \Sigma_l\, a_{k,l} \ln C_{kit} * \ln C_{lit} \\
& + a_4 \ln Z + 1/2\, a_{4,4} \ln Z * \ln Z + \Sigma_k\, a_{k,4} \ln C_{kit} * \ln Z \\
& + a_5 DP_{it} + a_6 DV1_{it} + a_7 DV2_{it} + a_8 DSS + a_9 DSIZE \\
& + a_{10} DR1 + a_{11} DR2 + a_{12} DR3 + a_{13} DR4 + \\
& + a_{14} DR5 + v_{it} - u_i \qquad (4.4)
\end{aligned}
$$

Again, the symmetry restriction will be imposed _a priori_, that is $a_{k,l} = a_{l,k}$, for all k and l. This implies that the coefficient of (1/2) will occur only if l = k. The definition of variables is the same as previously described.

4.2.2. Estimation Methods

As in the case of production function approach, two estimators, i.e., the within and EGLS estimators, are used in this study. In addition to these two estimators, the simple OLS estimator will also be presented for comparison purposes. The test to decide whether to use the within (fixed effects model) or the EGLS (random effects model) has been described in section 4.1.2.

The individual level of profit inefficiency is measured using the Battese and Coelli (1986) method as described in equation 3.25 in chapter 3. The methods presented in section 3.5, specifically equation (2.67) for FE model and equation (2.68) for RE model, will also be employed for comparison purposes.

4.3. System of Equations: Profit Function and Factor Share Equations

A system of equations consisting of a profit function and variable factor share equations can be regarded as a typical seemingly unrelated regression (SUR). As mentioned in chapter 3 section 3.3, in the non-frontier framework, some parameters of the profit function can be estimated either from the profit function itself or from the factor share functions. Theoretically, if profit maximizing conditions hold, the parameter estimates from the profit function have to be the same as the corresponding estimates from the factor share function. Thus, imposing an equality restriction will improve the efficiency of the estimates.

4.3.1. Model Selection and Functional Forms

Cobb-Douglas and translog profit functions, and corresponding factor share equations, are employed in the analysis. The specification and notation of the profit function of each functional form is the same as described in the previous section.

Cobb-Douglas Profit Function and Factor Share Equations

The Cobb-Douglas profit function and its corresponding variable factor share equation are specified as follows:

$$\ln\pi_{it} = \ln a_0 + \Sigma_k a_k \ln C_{kit} + a_4 \ln Z_{it} + a_5 DP_{it} + a_6 DV1_{it} + a_7 DV2_{it} + a_8 DSS + a_9 DSIZE + a_{10} DR1 + a_{11} DR2 + a_{12} DR3 + a_{13} DR4 + a_{14} DR5 + v_{it}$$

$$S_{ikt} = - C_{ikt} X_{ikt} / \pi_{it} = a_{ikt} + w_{ikt} \quad \text{(for } k = 1, 2, 3) \tag{4.5}$$

where S_{ik} is the k^{th} variable factor share for the i^{th} farmer, that is the ratio of the normalized k^{th} input value to the normalized restricted profit. The term w_{ikt} represents random noise, which is assumed to be distributed normally with a constant variance. Definition of other variables in the model is the same as that previously described.

Translog Profit Function and Factor Share Equations

A system of equations consisting of the translog profit function and variable factor share equations are:

$$\ln\pi_{it} = \ln a_0 + \Sigma_k a_k \ln C_{kit} + 1/2\, \Sigma_k \Sigma_l a_{k,l} \ln C_{kit} * \ln C_{lit} + a_4 \ln Z_{it} + 1/2\, a_{4,4} \ln Z_{it} * \ln Z_{it} + \Sigma_k a_{k,4} \ln C_{kit} * \ln Z_{it} + a_5 DP_{it} + a_6 DV1_{it} + a_7 DV2_{it} + a_8 DSS + a_9 DSIZE + a_{10} DR1 + a_{11} DR2 + a_{12} DR3 + a_{13} DR4 + a_{14} DR5 + v_{it} \tag{4.6}$$

$$S_{ikt} = - (C_{ikt} X_{ikt}) / \pi_{it} = a_k + \Sigma_l a_{k,l} \ln c_{ilt} + a_{k,4} \ln Z_{it} + w_{ikt} \quad \text{(for } k = 1, 2, 3)$$

The definition of the variables is the same as before.

4.3.2. Estimation Method

The concept of FE and RE models can be generalized beyond a single equation described above. Given a set of panel data, we can estimate a system of equations consisting of profit function and factor share equations. Single equation error component procedures outlined in the previous section can not be used to obtain efficient parameter estimates of a system of equations unless error correlations between equations are assumed to be zero.

The SUR type of model with error components can be estimated using the procedure outlined in the articles of Avery (1977) and in Baltagi (1980). The problem with this estimator, however, is that no ready computer packages are available at this time. Moreover, the transformation matrix required to use standard LS computer package is apparently very complicated and is not yet in the literature.

Given the above difficulties, the system of equations (4.5) and (4.6) will not be estimated using either the fixed effects or the error component framework. Instead they will be estimated using the Zellner's (1962) SUR method, applied on the pooled cross-section and time series data. This amounts to estimating the models in the non-frontier framework, and therefore, the individual specific effects (inefficiencies) will not be relevant in this case. A more detailed discussion of this approach, will be presented in the next chapter dealing with the empirical findings.

This approach is primarily intended to derive the profit maximizing (i.e., profit maximization as a maintained hypothesis) input demands and output supply, and related elasticity parameters. As mentioned in the previous chapter, some parameters of the profit function can be estimated either from the profit function itself or from the factor share functions. Theoretically, if the profit maximizing condition holds, the parameter estimates from the profit function have to be the same as the corresponding estimates from the factor share function. Thus, imposing equality restriction (i.e., profit maximization is maintained) will improve the efficiency of the estimates. Note, however, that profit maximization can alternatively be tested following the method of Yotopoulos and Lau (1979).

4.4. Multinomial Logit Model

4.4.1. Model Selection

Framers face three choices when selecting rice varieties: (i) to grow TV, (ii) to grow HYV, or (iii) to grow both TV and HYV, hereafter referred to as mixed varieties (MV). The multinomial logit model is used to evaluate economic factors affecting the probability of an individual farmer choosing one of those three alternatives. Five economic variables are hypothesized to affect farmers' decisions regarding varietal choice, i.e., prices of TV, HYV and fertilizer, labor wage, and farm size. The model to be estimated is specified as follows (omitting individual subscripts):

$$\ln(P_j/P_1) = \beta_{jo} + \Sigma_k \beta_{jk} X_k \tag{4.7}$$

where:

P_1 : probability of farmer growing TV.

P_j : where $j = 2, 3$, represent probability of farmer growing HYV and MV, respectively.

$k = 1, 2...5$, subscript for explanatory variables

X_1 = PTV : price of TV (Rp/kg)

X_2 = PHYV : price of HYV (Rp/kg)

X_3 = PF : price of fertilizer (Rp/kg)

X_4 = WAGE : labor wage (Rp/hour)

X_5 = HA : land in hectare.

Comparison for choice "3" and "2" can simply be made as

$$\ln(P_3/P_2) = (\beta_{3o} - \beta_{2o}) + \Sigma_k (\beta_{3k} - \beta_{2k})X_k \quad (4.8)$$

Having estimated the coefficient of β_2s and β_3s and the corresponding covariance we can then estimate the $(\beta_{3o} - \beta_{2o})$ and $(\beta_{3k} - \beta_{2k})$.

Fertilizer price, labor wage and farm size used in this model are similar to those used in the profit function model presented before. Prices of TV and HYV need some further explanation. The survey data provide either the TV or HYV price for the individual respondent, depending on the variety used. For example, from the respondent who grew TV, only the TV price was obtained. Thus, a value of the HYV price has to be assigned to this respondent. For this purpose, the average HYV price for each season is used. More troublesome is the case of farmers who grew both TV and HYV, since only one price was recorded without indicating whether it was a TV price or HYV price or an average of these two. In this case, the average prices of HYV and TV for each season are used.

Note that variable prices and labor wage used in this analysis are measured in nominal terms. The reason for using nominal rather than real (deflated) prices, is that farmers are commonly influenced by nominal price levels in their decision making process.

4.4.2. Estimation Method

The ML method will be used to estimate the model on the pooled data (N=1026). The GLS estimation, based on the availability of repeated observations, is not possible since many farmers did not switch from one choice to another, even though some did so. In addition, the time periods (T) are too short. Of course, it is also possible to estimate a seasonal (pure cross-sectional) multinomial logit model using ML method. A primary reason to pool the data is to obtain larger variation on the price (wage) variables.

4.5. Evaluation of Price Support and Fertilizer Subsidy Policies

In this study, we attempt to evaluate rice price support and fertilizer subsidy policies, focusing on their impact on increasing total rice production as well as promoting rural employment. The evaluation is based on the estimated cross- and own-price elasticities of the rice supply and variable input demand, obtained from the analysis outlined above. In addition, we need the following information: (i) total quantity of subsidized fertilizer for rice production, (ii) total quantity of excess rice supply in the market purchased by the government, and (iii) total rice production, (iv) total labor used in the rice production, (v) the price of rough rice, and (vi) the price of fertilizer.

The main idea of the proposed evaluation procedure is to compare the rice price support and fertilizer subsidy policies in terms of their costs to the government in producing an additional kilogram of rough rice and in promoting an additional unit of employment in the rural area. The desirable policy is the one which is less costly. The procedure involves the following calculation:

(1) <u>Price Support on Rice: 1% increase in Rice Price</u>

a. Government's additional cost:

$$GPR = 0.01 * P_R * Q_{ER} \tag{4.9}$$

b. Effects on:

b1. Rice Production:

$$AQ_{RP(1)} = E_{RR} * 0.01 * Q_{RP} \tag{4.10}$$

b2. Rural Employment:

$$AQ_{L(1)} = E_{LR} * 0.01 * Q_{LRP} \tag{4.11}$$

(2) <u>Fertilizer Subsidy Policy: 1% Decrease (Subsidy) in Fertilizer Price</u>

a. Government's additional cost:

$$GPF = 0.01 * P_F * Q_{FSR} \tag{4.12}$$

b. Effects on:

b1. Rice Production:

$$AQ_{RP(2)} = E_{RF} * 0.01 * Q_{RP} \tag{4.13}$$

b2. Rural Employment:

$$AQ_{L(2)} = E_{LF} * 0.01 * Q_{LRP} \tag{4.14}$$

The definition of the variables is as follows:

Q_{RP} = total rice production (ton/year)

Q_{ER} = total excess supply of rice purchased by the government (ton/year)

Q_{FSR} = total quantity of subsidized fertilizer used in rice production (ton/year)

Q_{LRP} = total labor used in rice production (mandays/year)

GPR = governments' additional costs due to specified price support policy (Rp/year)

GPF = government's additional costs due to specified fertilizer subsidy policy (Rp/year)

$AQ_{RP(1)}$ = additional quantity of rice production due to specified price support policy (ton/year)

$AQ_{RP(2)}$ = additional rice production due to specified fertilizer subsidy policy (ton/year)

$AQ_{L(1)}$ = additional rural employment due to specified price support policy (mandays/year)

$AQ_{L(2)}$ = additional rural employment due to specified fertilizer subsidy policy (mandays/year)

P_R = price of rice (Rp/ton)

P_F = price of fertilizer (Rp/ton)

E_{RR} = estimated own-price elasticity of rice supply

E_{RF} = estimated cross-price elasticity of rice supply with respect to fertilizer price

E_{LR} = Estimated cross-price elasticity of labor demand with respect to price of rice

E_{LF} = estimated cross-price elasticity of labor demand with respect to price of fertilizer

In the equation (4.9), based on empirical evidence discussed in the next chapter, we assume that no additional excess supply of rice must be purchased by the government as a result of a one percent increase in the price of rice. Stated differently, the additional excess supply of rice which is purchased by the government is small, and can be ignored. The additional government cost is therefore equal to the product of the increase in the unit price and the total rice previously purchased, as in equation (4.9). A similar assumption in the case of fertilizer, equation (4.12), is also made. Next we need to calculate the government's costs per additional unit of rice (Rp/kg) as well as the costs for every additional unit of employment opportunity (Rp/manday) generated by each policy, as follows:

(1) <u>Price Support on Rice: 1% Increase in Rice Price</u>

(b) Cost per unit of rice produced:

$$C_{R(1)} = GPR/AQ_{RP(1)}$$

(b) Cost per unit of employment generated:

$$C_{L(1)} = GPR/AQ_{L(1)}$$

(2) <u>Fertilizer Subsidy Policy: 1% Decrease in Fertilizer Price</u>

(a) Cost per unit of rice produced:

$$C_{R(2)} = GPF/AQ_{RP(2)}$$

(b) Cost per unit employment generate:

$$C_{L(2)} = GPF/AQ_{L(2)}$$

The final step of the proposed procedure is comparing $C_{R(1)}$ against $C_{R(2)}$ and $C_{L(1)}$ against $C_{L(2)}$. The smaller the value, the more desirable is the policy in question.

The critical points of this procedure will be on estimating the Q_{ER} as well as the Q_{FSR}. The better the estimates, the more reliable is the conclusion made. This procedure only evaluates the impacts of the policy alternatives on the government budget, and ignores the welfare impact on consumers and producers of rice. Even though the procedure described here is very rough, it provides a simple measure for identifying the more cost-effective policy alternative for attaining the specified policy goals.

4.6. Data Transformation

Land Size

Farmers in the survey area often do not have contiguous plots of land to cultivate, but rather have several parcels scattered throughout the village area. Land or farm size, in this analysis, is defined as the total area that farmers cultivate with rice. The survey did not record input-output data for each parcel; instead it recorded the total inputs used and total output of the whole hectareage. Some farmers may plant other crops in some of their parcels, but these parcels, including the crops, are excluded from the analysis. Note that the terms of "land" and "farm size" are used interchangeably in this study.

Fertilizer, Fertilizer Price and Cost

Two types of fertilizers are commonly used by farmers, namely N (Nitrogen) in the form of urea (48% N) and P (Phosphorus) in the form of TSP (Triple Super Phosphate, 46% P). The amount of fertilizer in this analysis, which is measured in kilograms (kg), represents the bulk of urea and TSP, respectively. These fertilizers are part of the BIMAS credit package, but non-BIMAS farmers as well can easily find these fertilizers at the local market.

As mentioned in chapter 1, the price of fertilizer is set by the government as part of input subsidization policies. The price of these two fertilizers is officially the same. Prices on local markets, however, are sometimes lower than the BIMAS price and the price of urea and TSP may differ from each other. In this analysis the price of fertilizer is the weighted average of the prices of urea and TSP paid by farmers, and is obtained by dividing the total costs of fertilizers (urea and TSP) by the total quantity used.

Seed, Seed Price and Seed Cost

Farmers may use seed they produce themselves or they may purchase seed from the village cooperative unit. The latter (certified seed) is usually available in the village unit, and has a higher germination rate than self-produced seeds. Therefore, farmers who use self-produced seed usually use more seed per unit of land.

The price of seed per kilogram recorded in this survey is based on information obtained directly from the farmer. There is no information regarding the type of seed used by the farmer. This, however, can be inferred from the price and the quantity recorded in the survey. Low price and large quantity per unit of land may indicate use of self-produced seed.

Labor, Labor Wage and Labor Cost

The measurement of labor units and wages is more complex than for other inputs. There are two kinds of laborers in the rice production reported in the survey: (i) human labor, and (ii) animal (bullock) labor. Although the use of tractors is not uncommon, there was no tractor use reported in the survey. The two categories of labor are subdivided into family labor and hired labor.

Human labor consists of male and female, the wage and quality of which this study assumes is equal. It is true that male labor may be superior in one type of job while female is superior for another. Male labor usually is applied to land preparation, while female labor is applied to planting and crop management.

The wage for hired labor, except for harvesting, is usually paid in a combination of cash and food. The actual wage per unit of time varies among farmers due to the valuation of food given to the labor. Wages also vary according to sex and the type of work performed. The male wage for plowing, for instance, is usually higher than the male wage for weeding. In some villages, the male wage is higher than the female wage for the same type of work performed.

Harvesting involves cutting paddy in the field, carrying it to the owner's home, and separating the rough rice from the straw. Harvest workers are commonly paid in terms of rough rice, as a portion of the total amount of rough rice they have collected. This portion, which is called "bawon", varies among farmers. In general it is determined on the basis of local custom, and the distance of the paddy field to the owner's home. It is necessary to note that the number of workers involved in harvesting is large but not precisely known.

In this study, animal labor is converted into human labor using the animal and human labor wage ratio as the weight. Thus it is the total money wages of animal labor divided by the average wage of human labor paid by the farmer. Similarly, the total amount of labor in harvesting is simply the total money wage divided by the average human labor wage paid by the farmer. The total money wage of harvesting is approximated by multiplying the amount of rough rice paid to harvest workers by the price of rough rice. The amount of labor, in hours, is the total labors used in the production process including the labor used in harvesting.

Output and Output Price

Output is measured in kilograms of rough rice. It is the total of rough rice before deducting harvest wage. The price of rough rice (Rp/kg) is used in this analysis, and it is the price farmers gave in the survey response. The variation of the output price is usually attributable to variety, moisture content and other criteria related to rice quality. TV are usually more expensive than HYV.

Total Revenue and Restricted Profit

Revenue is defined as quantity of output multiplied by the price of output. As mentioned before, restricted profit is defined as profit over variable costs, which in a sense is a return attributable to the fixed costs. Labor, seed and fertilizer are treated as variable inputs, while land is the fixed input. Total variable cost is computed as the sum of seed cost, fertilizer cost and labor cost.

V. EMPIRICAL RESULTS AND DISCUSSION

This chapter consists of six sections and is organized as follows. The first section presents the results of a descriptive analysis of the data. A discussion of production function parameters and technical and allocative inefficiency is covered in section two, followed by section three which presents results of the profit function approach. The discussion on output supply and derived input demand is covered in section four. It should be pointed out that the results presented in sections two and three are based on the estimation of the single equation, i.e., direct estimation of production and profit function, while the results in section four are based on an equation system estimation procedure. Section five describes the results of the estimated multinomial logit model, emphasizing on the discussion of the factors affecting the adoption of the high yielding rice varieties. Finally, section six attempts to evaluate the rice price support and fertilizer subsidy policies using the proposed evaluation procedure described in previous chapter.

5.1. Results of Descriptive Analysis

Some simple statistics on the data are presented before proceeding to more complicated analysis. Statistics such as mean values, provide basic information which assists in understanding the more advanced analysis. However, caution should be used in interpreting such statistics since they could easily lead to wrong conclusions. The results of analysis of variance for seasonal and varietal comparisons are also presented.

The mean values of the quantities of inputs and output, prices, costs and profit are presented in Table 5.1. The standard deviation of the mean values of each variable are also computed but not presented here. The figures presented in Table 5.1 were obtained by first calculating the per hectare measure of the individual farm and then averaging this measure over individuals. The per hectare measure of the inputs and output will tend to be overestimated if the size of cultivated land is very small.

The result shows that the average size cultivated land during the dry season is smaller than average size during the wet season. Avoiding drought risk, lack of irrigation water due to inappropriate irrigation systems, and growing relatively less risky crops (secondary crops and vegetables) could be the reasons for the seasonal difference. In some villages, as described in section 2.2.4, farmers cultivate part of their land with secondary crops and vegetables in the dry season. The result of the analysis of variance indicates that the seasonal difference in farm size is in fact significant at the 0.01 level. However, there is little tendency of decreasing farm size over time.

The average rice yield is greater for the wet season than for the dry season. This is because farmers use greater amounts of fertilizer in the wet season than in the dry season. There is no information to explain the low yield of the wet season 1976/1977. The dry season of 1977 was relatively long, causing significant yield reductions. The result of the analysis of variance confirms that seasonal yield difference is in fact significant at 0.10 significant level, with the computed F-statistic = 2.80.

Table 5.1. Mean Values of Input and Output Per Hectare for Rice Farm

Input and Output	Season (W=Wet, D=Dry)					
	W75/76	D76	W76/77	D77	W82/83	D83
Land (Ha)	0.5054	0.3798	0.4522	0.3583	0.4812	0.4219
Output (Kg/Ha)	3216.6	3030.9	2515.7	2358.6	4196.8	4003.0
Seed (Kg/Ha)	39.5	45.5	40.6	38.3	42.3	38.2
Urea (kg/Ha)	194.4	186.8	219.9	198.5	267.9	251.8
TSP (kg/Ha)	59.0	53.0	63.4	58.2	119.8	111.9
Labor (hrs/ha)	1429.4	1311.4	1193.9	1259.0	1421.3	1390.7
Hired preharvest	623.4	547.7	484.5	542.6	562.3	520.9
Hired harvest	508.5	456.9	368.5	358.1	447.4	473.7
Family	297.5	306.7	340.9	348.3	414.7	396.1
Price (Rp/Kg):						
Rough Rice	62.57	66.94	65.29	74.58	127.21	149.19
Seed	68.75	72.04	74.98	94.49	176.49	185.68
Urea	79.81	79.72	70.58	70.92	87.50	89.65
TSP	78.14	79.56	70.49	71.28	89.08	90.85
Wage	49.50	48.40	55.83	51.99	139.08	137.74
Revenue (Rp/Ha)	201255	202892	164238	175899	533846	597198
Var.Cost (Rp/Kg)	103857	95499	103136	102439	279079	271033
Profit (Rp/Kg)	97398	107393	61102	73460	254767	326166

The amount of seed used is relatively stable over time. There is no consistent relationship between the amount of seed used and season. For example, the amount of seed used per hectare for the wet season of 1975/76 is smaller than for the dry season of 1976, while the opposite is true for the rest of the period. The result of the analysis of variance, where the computed F-value is 0.92, supports the conclusion that there is no seasonal difference in the quantity of seed per hectare.

The amount of fertilizer used per hectare tends to increase over time. The mean of the fertilizer use per hectare, except for the last two seasons of the observation, is lower compared to the recommended rate of the BIMAS program (see appendix 2.1). The recommended urea and TSP application, under package C of the BIMAS program, are 250 kg and 75 kg per hectare, respectively. The result also shows that farmers use more fertilizer in the wet season than in the dry season. This may be because soil moisture content in the wet season is usually more appropriate for higher levels of fertilizer application than in the dry season. The computed F-value for urea is 3.78 (α=0.05), while the computed F-value for TSP is 2.99 (α=0.08). This result indicates that the seasonal difference in fertilizer application is more significant for urea than for TSP.

There are no apparent seasonal differences in the means of quantity of labor use per hectare. The result of the analysis of variance, however, indicates that the seasonal difference is in fact significant at the 10% significance level. About 70-80% of labor used per hectare is hired labor. This is surprising since the majority of the farmers in this study have farms less than 0.65 hectare, and were expected to be more dependent on family labor. The fact that family labor is only a small portion of the total labor use justifies the use of the current labor wage as opportunity cost of labor to calculate the imputed labor cost of family labor.

As discussed in chapter 1, the government sets the price of rough rice and the price of fertilizer. The average price of rough rice actually received by the farmers is very close to the floor price. Similarly, farmers buy fertilizer at prices close to the government-established price. The government policy to control fertilizer prices has thus been very effective, primarily because fertilizer is part of the BIMAS credit program for rice farmers. The nominal labor wage, which the government has no direct control, has increased faster than the prices of rough rice and of fertilizer.

The figures of nominal prices, costs, and profit show a significant positive trend, particularly in the period of 1977-1982. This is due to a high inflation rate within this period. It should be pointed out that the Indonesian government devalued the rupiah twice during this period, in November 1978 from Rp 415/US$ to Rp 615/US$, and in March 1983 from Rp 615/US$ to Rp 970/US$. Table 5.2 shows no significant positive trend in real (deflated) prices. It is not surprising that the real prices of fertilizer and rough rice have decreased over time, as a result of government price controls.

As discussed in chapter 1, the government sets the price of rough rice and the price of fertilizer. The average price of rough rice actually received by the farmers is very close to the floor price. Similarly, farmers buy fertilizer at prices close to the government-established price. The government policy to control fertilizer prices has thus been very effective, primarily because fertilizer is part of the BIMAS credit program for rice farmers. Table 5.2 also shows that the wage rate has increased faster than the prices of rough rice and of fertilizer.

Table 5.2. Deflated Prices of Inputs, Rough Rice and Profit

	Season (W=Wet, D=Dry)					
	W75/76	D76	W76/77	D77	W82/83	D83
RCPI*	225	283	292	301	654	710
Deflator	1.00	1.25	1.30	1.34	2.90	3.15
Rough Rice	62.57	55.78	50.22	55.22	43.86	47.36
Seed	68.75	57.63	57.68	70.51	60.86	58.95
Fertilizer**	78.98	63.71	54.26	53.06	30.44	28.65
Labor	49.50	38.80	42.95	38.80	47.49	43.73
Profit	97398	85915	47002	54821	87851	103545

* Source: CBS, 1983.
** Simple average of the urea and TSP figures in Table 5.1
RCPI: Price indexes of 9 essential goods in rural area.

The government operates a parallel system of rice procurement and distribution, partly to provide civil servants, army officers and other budgetary group members with a monthly rice ration and partly to hold as a buffer stock for stabilizing rice price in domestic market (Tabor, 1988). BULOG (National Logistic Agency), acting through it's network of DOLOGs (Logistic Depots) or through a procurement Task Force, purchases rough rice or rice, mainly from private mills and partly from government sponsored farmers' cooperatives. Rice is purchased at a floor price set by the government prior to the planting season. Thus, the government purchases rice not only when the market price of rice is below the floor price, but it purchases rice in order to maintain rice stocks for monthly rice rations, in addition to maintaining the buffer stocks for rice price stabilization. When price rises above a ceiling price level, the government begins to distribute rice. Market operations continue in an effort to maintain prices below the target ceiling price. The floor price is set uniformly for the entire nation, but the target ceiling price is set differently so as to allow for normal movement of rice from surplus to deficit regions.

Appendices 5.1, 5.2 and 5.3 present the mean values of the per hectare quantities of inputs and output, costs and profit of the HYV, TV and MV (mixed-variety) of rice, respectively. Detailed discussion and comparison of these three groups of farmers will not be made in this section. However, some interesting findings need to be mentioned here.

The average land of the HYV farmers is larger than the average land of the TV farmers. This indicates that large farmers are more responsive to new technology than small farmers. Large farmers are relatively wealthier and usually have more access to credit than small farmers. On the average, the HYV farmers use more urea than TV farmers. This is understandable since HYVs tend to be more responsive to fertilizer application (as well as to water availability). Moreover, the HYV farmers are mostly large farmers, who can afford fertilizer. As a result of a significantly higher urea applications, the yield of the HYV farmers is on the average much higher than the yield of TV farmers. The average quantities of seed, TSP and labor per hectare are not significantly different between these two groups. The results of the analysis of variance support all these conclusions.

5.2. Production Function and Production Inefficiency

In addition to obtaining production elasticities, this approach is intended to evaluate the level of technical inefficiency of individual rice-producing farms. Two functional forms of stochastic production frontiers, i.e., Cobb-Douglas and translog, are estimated from panel data (N=171 and T=6). The reason for estimating the translog production function, in addition to obtaining non-constant production elasticities, is to examine whether the individual level of technical inefficiency is invariant to the functional form.

It is assumed that the elasticities of production are constant between firms and over time. This assumption may become increasingly difficult to defend as the time span of the observations increases. However, for the four-year period of the sample, the assumption seems fairly reasonable.

One purpose of this study was to compare farmers who planted HYV with those who planted TV rice. However, the survey reported that some farmers switched from HYV to TV or to mixed varieties (HYV and TV), during the six periods of the survey. Separate analysis of TV and HYV is therefore not possible in the panel data analysis framework. The separation of these two varieties is possible using a dummy variable which varies over time (dummy intercept, dummy slope or both). This dummy variable can be treated as other time varying variables in the panel data framework. Pesticide use will also be treated like the dummy for rice variety.

5.2.1. Cobb-Douglas Production Function

Three estimators were used, namely the ordinary least squares (OLS), the dummy variable (within) and the EGLS estimator. Recall that only the last two estimators yield a frontier function, while the OLS, which is intended for comparison purposes, gives the usual non-frontier function. The OLS estimator is obtained simply by applying the ordinary least squares method to the pooled data. The dummy variable estimator, hereafter referred to as within estimator, is obtained by applying OLS to the transformed data, that is after transforming the data in terms of deviations from individual means. The EGLS estimator, which can be viewed as a weighted average of the within and the between estimator, is calculated by first transforming the data in terms of deviations from a fraction of the individual means and then running OLS on the transformed data. These three estimators are described in chapter 3, section 3.1.1 and 3.1.2.

Three statistical tests were performed. The first test is related to the fixed effect (FE) specification to test the null hypothesis that individuals have the same intercept against the alternative hypothesis that their intercepts are not the same. The computed F-statistic (equation 3.7) equals 1.4818 and the critical $F_{0.05}(170, 845)$ equals 1.2214. Thus, the null hypothesis is rejected at the 0.05 significance level.

The second test is the LM test (equation 3.19), related to random effect (RE) specification to test the presence of individual random effects by testing the null hypothesis that σ_u^2 equals zero. The computed LM statistic equals 9.5864 and the critical $Chi^2(1)_{0.05}$ equals 3.8415. Since the LM statistic is larger than its critical value, we can therefore reject the null hypothesis. This implies that individual random effects exist.

The third test was performed on the null hypothesis that there is no correlation between the individual effects and the included variables against the alternative hypothesis that such correlation exists. The results determine whether to use RE or FE specification. The Mundlak test (equation 3.21) was used in this case. The computed F-statistic is 1.5378 while the critical $F_{0.05}(8, 1009)$ is 1.9384. Thus the RE model rather than the FE model is justified statistically. Note that in performing the Mundlak test, only the time-varying variables which are statistically significant were included.

In order to examine the difference between OLS, within and EGLS estimators, the results are presented in Table 5.3. The individual intercepts of the within estimator, which can be estimated directly by using equation (3.5b), are not presented here. The results show that the parameter estimates of the EGLS lie between the corresponding parameter estimates of the other two estimators. The EGLS estimator gives the best fit of the production function compared to the others. The computed coefficient of multiple determination (R^2) of the EGLS estimator equals 0.9967, meaning that almost one hundred percent of the variation of the dependent variable is associated with the variation of the specified independent variables in the model. The R^2 of OLS and the within estimators are 0.8843 and 0.7497, respectively.

The sign of the coefficients estimated by OLS and EGLS is the same and the magnitudes are very close to each other. This is not too surprising, since the (1 - w) is very small, and therefore running LS regression on the transformed data (EGLS estimator) yields similar results to running LS regression on the original data (OLS estimator). Note that "w" measures the weight given to the between-individual variation. In the covariance (within) estimator, this variation is completely ignored (w=0), while in the OLS estimator this variation is completely incorporated (w=1).

Table 5.3. Estimated Parameters of the Cobb-Douglas Production Function

Independent Variables	Estimation Methods		
	OLS	Within	GLS
Constant	5.0868*** (0.1916)	-	5.0690*** (0.1938)
LKGS	0.1339*** (0.0271)	0.1176*** (0.0271)	0.1304*** (0.0271)
LKGN	0.1175*** (0.0175)	0.0878*** (0.0193)	0.1110*** (0.0179)
LKGP	0.0735*** (0.0114)	0.0912*** (0.0116)	0.0778*** (0.0115)
LLAB	0.2159*** (0.0288)	0.2378*** (0.0296)	0.2211*** (0.0290)
LHA	0.4759*** (0.0318)	0.4323*** (0.0333)	0.4676*** (0.0321)
DP	0.0066 (0.0284)	0.0325 (0.0293)	0.0127 (0.0286)
DV1	0.1743*** (0.0385)	0.1768*** (0.0377)	0.1756*** (0.0383)
DV2	0.1389*** (0.0541)	0.1792*** (0.0531)	0.1477*** (0.0539)
DSIZE	0.0198 (0.0359)	0.0881** (0.0400)	0.0349 (0.0368)
DSS	0.0496** (0.0218)	0.0555*** (0.0196)	0.0503** (0.0211)
DR1	-0.0505 (0.0435)	-	-0.0519 (0.0499)
DR2	-0.0403 (0.0546)	-	-0.0465 (0.0591)
DR3	-0.0640 (0.0575)	-	-0.0736 (0.0621)

Table 5.3 (continued)

DR4	0.0240 (0.0527)	-	0.0118 (0.0585)
DR5	0.0801 (0.0557)	-	0.0734 (0.0602)
σ_v^2	-	0.1069	0.1069
σ^2	-	-	0.1526
σ_u^2	-	-	0.0076
$w=\sigma_v/\sigma$	-	-	0.8372
$\theta = 1 - w$	-	-	0.1628
E[u]	-	-	0.071
F-Statistic	514.70	304.34	19208.10
R^2	0.8843	0.7497	0.9967
N (individuals)	171	171	171
T (seasons)	6	6	6

Variable definition can be seen in chapter 4 or appendix 5.4
Figures in parentheses are standard deviations
*** statistically significant at α=0.01
** statistically significant at α=0.05
* statistically significant at α=0.10

The results also show little difference in magnitude between the EGLS estimator and corresponding estimate of the within estimator, and no difference in the sign of the estimate. This is consistent with the result of the model specification test previously described. If the null hypothesis that E[X'u]=0 holds, and in fact it is not rejected by the test, the EGLS estimator should not be very different from the within estimator. The significant difference between these two estimators indicates that the alternative hypothesis holds. This is the basic idea underlying the Hausman test, or equivalently the Mundlak test.

The EGLS estimators for the production elasticities with respect to seed, urea fertilizer and land are greater than the corresponding elasticities of the within estimator. For production elasticities with respect to phosphate fertilizer and labor, the reverse is true. The returns to scale coefficients of these three estimators are 1.0167, 0.9667 and 1.0082, respectively, for OLS, within, and EGLS. A statistical test performed, to test the null hypothesis of constant returns to scale, could not reject the null hypothesis at the 0.10 level. Thus, these three estimates confirm that the rice production technology is in the stage of constant returns to scale.

The following discussion will focus only on the EGLS estimates. However, some comparisons to the within estimates might be made. Before proceeding to production elasticities, let us first interpret the coefficient estimates of the dummy variables. The dummy variable for pesticide use is not significant, indicating the use of pesticide does not have any effect on the level of production. It was reported that during survey periods no significant crop damage due to insect attack or plant diseases occurred in the study area. The dummy variables of HYV and MV are significant at the 0.01 level. Thus, farmers with HYV and MV produce more output than TV farmers. This is consistent with a priori expectation.

The season dummy has a positive sign and is significant at the 0.05 significance level. This indicates that the level of production is greater in the wet season than in the dry season. This is understandable because the soil moisture content in the wet season is usually more optimal for plant growth than in the dry season. In addition, the optimality of soil moisture content induces farmers to use more fertilizers, which in turn increases rice yield. Thus, the lack of water during the dry season is possibly the key reason for the seasonal yield difference. As mentioned in chapter 2, most of the rice fields lack water during dry seasons. The difference in the level of production is represented directly by the coefficient for the season dummy.

The regression coefficient for the farm size dummy is not significant, indicating that there is no significant difference in productivity between small and large farmers. The region dummies representing individual non-specific time invariant variables such as climate and soil quality, are not significantly different from zero. This result indicates that there is no signifant difference, statistically, in the level of per household production between regions. The nation-wide rice intensification program (BIMAS/INMAS), which has already been implemented intensively since the early 1960's, particularly in West Java, could be the main reason.

The interpretation of a Cobb-Douglas production function is very simple and straightforward, since the regression coefficients directly represent the production elasticities of the corresponding independent variables (inputs). Table 5.3 shows that all input coefficients have correct signs and are significantly different from zero at the 0.01 level. The seed coefficient of 0.1300, indicates that a one percent increase in quantity of seed, other things being fixed (*ceteris paribus*), will result in 0.13 percent increase in the level of rice production.

The production elasticities with respect to urea and TSP fertilizer equal 0.1110 and 0.0778, respectively, and both are significant at the 0.001 level. The result shows that rice is more responsive to N fertilizer than P fertilizer. The slow decomposition of phosphorus relative to nitrogen in the soil could be the reason for this difference. Thus the paddy fields may have sufficient phosphorus, but insufficient nitrogen, resulting in a relatively smaller yield response from additional phosphorus compared to yield response from additional nitrogen. The fact that the production elasticities of these two fertilizers are different could be used to support the argument for differentiating the prices of these two fertilizers. This is particularly important if the government aims to gradually reduce fertilizer subsidies. Up to now, however, the prices of these two fertilizers are kept the same by the government.

The production elasticity with respect to labor is 0.22. This means that a one percent increase in labor hours will increase the production level by 0.22 percent. Similarly, the interpretation of the production elasticity with respect to land is that a one percent increase in area cultivated per household will result in 0.47 percent of increase in the level of production, indicating the condition of diminishing marginal returns to land.

As mentioned before, the results also show that rice production in west Java is in the stage of constant returns to scale. The test of the hypothesis of constant returns to scale could not be rejected at the 0.10 significance level. This means that a one percent increase of all inputs will result in a one percent increase in the level of production. If this is true, natural land consolidation which has occurred in some places would not have any effect in increasing total rice production, although some advantages may occur particularly those related to post harvest activities such as product processing and marketing.

One of the weaknesses of the Cobb-Douglas type of functional form is that it has a constant elasticity property at any level of output and input use. This difficult to defend both theoretically and empirically. Another serious weakness of this functional form is the well known property of constant unitary elasticity of input substitution which will be discussed later in relation to the estimation of cross-price elasticities of the input demand function.

Let us now turn to technical inefficiency measures. Individual level of technical inefficiency is estimated using three different methods. The first method obtains individual technical inefficiency by differencing the individual intercepts from the intercept of the most efficient farm, as in equation (3.67). The second method is based on the residual of the EGLS estimator as presented in equation (3.68). The third method is the one suggested by Battese and Coelli (1986) as presented in equation (3.69). Note that these methods, particularly for the first two, give consistent estimates of individual effects (u_i) only if both N and T are large. Since in our case T is relatively small, the consistency of the estimates of u_i is questionable. The first two methods do not use any distributional assumptions regarding u_i, while the third method uses a half-normal distribution with mode at $u_i = 0$

The first two methods give much larger estimates than the third one. In the case of the first method, the estimate of u_i may always be larger than the others since it includes the effects of time invariant variables which could not be included in the model. Given the obvious disadvantage of the first two methods, their estimation results are not discussed. However, it is important to note that although the magnitudes of these three estimators are quite different, the individual ranks based on the level of efficiency are quite similar.

The estimates of the individual level of technical inefficiency and their ranks, based on the third method (equation 3.69), are presented in appendix 5.5. The range of technical inefficiency using the third method is 3.4% - 12%, with the mean of 6.5%. The mean is 7% if the calculation is based on equation (3.24a). This figure tells us that rice farms in West Java are, on the average, 6.5% technically inefficient or 93.5% technically efficient. One could also interpret that the fitted individual production function is 3.4% - 12%, or 6.5% on the average, below the frontier production function. Given the intensive nature of wetland rice farming in West Java, this relatively small figure of technical inefficiency is reasonable. The figure, presumably, would be much greater in the case of dryland rice farming since the government has given relatively less attention to intensifying dryland farming.

Policy implications of the efficiency measure are debatable. Some advocates of frontier analysis claim that a firm can move from the interior of the production function surface to the frontier without any cost to the firm. They assert that better use of the existing technology in terms of cultivation and crop-management practices will definitely increase yield. They do not, however, specifically address the question of how this can be achieved. On the other hand, nonadvocates would argue that free correction is very unrealistic, since movement to frontier requires adjustments of factors of production including management skills which could be regarded as a fixed factor. Improving management skills is of course not without cost.

Table 5.4 shows that no significant difference in the level technical inefficiency between small farms and large farms; small farms may or may not be more technically efficient than large farms or vise versa. This is consistent with the regression results which yield a coefficient on the farm size dummy variable not significantly different from zero. Therefore, it seems reasonable to interpret the mean of technical inefficiency level (6.5%), as a per-hectare output loss due to technical inefficiency. Alternatively, we can simply reestimate a per-hectare production frontier and find both the mean and the individual level of technical inefficiency.

Using rice yield (kg/ha) figures as presented in Table 5.1, and the annual harvested area of rice farms in West Java (1.74 million hectares), we could roughly estimate the annual output loss due to technical inefficiency. Using rice yield for the 1983 dry season (4003 kg/ha), the per-hectare quantity of rice loss was 260 kg, and the total quantity of rice loss in West Java rice farms would be 0.45 million ton annually. Thus, better use of existing technology of rice production provides an opportunity to somewhat increase rice yield and total rice production in West Java.

Table 5.4. Frequency Distribution of Farmers Based on The Level of Technical Inefficiency from the Cobb-Douglas Production Frontier

Range of Technical Inefficiency	% farms		% from total farms
	$\leq$ 0.5 Ha	> 0.5 Ha	
$\leq$ 5%	13.4	13.6	13.5
5% < u $\leq$ 10%	83.5	84.1	83.6
10% < u $\leq$ 15%	3.1	2.3	2.9
Total %	100	100	100
Total farms	127	44	171

Let us now evaluate allocative efficiency of the input use. As mentioned in chapter 3, a farm is allocatively efficient if the input use maximizes profit, that is if the value of marginal product (VMP) of particular input equals its marginal factor cost (MFC). This condition implies that at the point of profit maximization, the ratio (d) of VMP to MFC for each input is equal to one. This also means that the last dollar spent on each input must return exactly one dollar, and most if not all previous units will have given back more than a dollar (Debertin, 1986). The accumulation of the excess dollars in returns over costs represents the profits or net revenues accruing to the farm.

A simple evaluation for allocative inefficiency can be conducted by calculating the "d" ratio for individual farm based on the estimated production function and the price levels reported in the survey. There is no intention to interpret the level of allocative (in)efficiencies for an individual farm. Seasonal average and grand average values of the "d" ratio for each input are presented in Table (5.5). On the (grand) average the "d" ratio for seed, urea, TSP, and labor are 10.34, 3.09, 14.60, and 0.89, respectively, indicating underutilization of seed and fertilizers and overutilization of labor. This, however, does not necessarily mean that farmers do not attempt to maximize profits; rather it may mean that farmers, for various reasons, were not able to maximize profit.

Table 5.5. Allocative Inefficiency Measures ("d" ratio) in Rice Production.

Season	Seed	Urea	Phosphate	Labor
W-75/76	12.04	3.74	16.74	1.06
D-76	11.45	3.79	19.38	0.93
W-76/77	8.58	2.46	17.00	0.78
D-77	7.39	2.97	16.11	0.74
W-82/83	10.67	2.58	6.03	0.85
D-83	11.92	3.04	12.37	1.03
Average	10.34	3.09	14.60	0.89

5.2.2. Translog Production Function

As in the case of Cobb-Douglas, the translog production function is estimated using three different estimators, namely OLS, the within and EGLS. However, none of the statistical tests outlined in section 5.2.1. is repeated here.

The regression result is presented in Table 5.6. An F test was conducted to test the null hypothesis that all coefficients of the second order terms of the inputs are equal to zero, in order to test whether a Cobb-Douglas functional form is the correct one. The computed F(15,995) statistic is 6.3868, while the critical $F_{0.05}(15,995)$ is 1.6664. The null hypothesis, therefore, is rejected.

Further examination, however, indicates that this model suffers from serious multicollinearity problems, since numerous regression coefficients were not significant at 0.01-0.10 significance level while the computed

F-value of the model was very high. Although multicollinearity does not cause bias of the estimates, it does enlarge the variance of the estimates, resulting in a greater tendency to accept the null hypothesis. To more formally measure the degree of multicollinearity, one can compare the coefficient of multiple determination (R^2) of the model and the R^2 of each auxiliary regression (i.e., regression between each independent variable and the remaining independent variables). If R^2 of the main regression is greater than R^2 of the auxiliary regression the presence of multicollinearity can be ignored.

Because multicollinearity is directly dependent upon the sample of observations, little can be done to resolve it unless more information is available. The information may be additional sample observations or non-sample information (i.e., imposing restrictions on the parameter space). The second choice is sometimes preferable, though not without risk, since the first choice is usually very costly and/or may not be feasible. Since non-sample information is uncertain, its use may or may not improve estimator performance in repeated sampling, although its use does ensure that the variances of the parameter estimates are reduced. Using incorrect restrictions incurs the risk of biasedness of the parameter estimates. On the other hand, if nonsample information exists about which we are relatively certain, then it can be used in conjunction with the sample data to obtain more precise estimators (Fomby et al., 1984). More discussion about multicollinearity problem will be given later in relation to the estimation of output supply and input demand elasticities.

Table 5.6. Estimated Parameters of the Translog Production Function

Independent Variables	Estimation Methods OLS	Within	GLS
Constant	2.8946* (1.8055)	-	2.9631* (1.7896)
LKGS	1.1509*** (0.3699)	1.0506*** (0.3636)	1.1297*** (0.3682)
LKGN	0.1165 (0.1628)	0.3251 (0.2587)	0.1763 (0.2617)
LKGP	-0.3551** (0.1639)	-0.4471*** (0.1596)	-0.3742** (0.1621)
LLAB	0.6856 (0.5801)	0.5188 (0.5656)	0.6407 (0.5759)
0.5*LKGSKGS	-0.0259 (0.0246)	-0.0241 (0.0244)	-0.0265 (0.0245)
LKGSKGN	-0.0088 (0.0376)	-0.0069 (0.0365)	-0.0074 (0.0372)
LKGSKGP	0.0536** (0.0236)	0.0555** (0.0230)	0.0549** (0.0234)
LKGSLAB	-0.1587*** (0.0614)	-0.1502*** (0.0606)	-0.1578*** (0.0612)
0.5*LKGNKGN	0.0029 (0.0140)	-0.0027 (0.0137)	0.0017 (0.0139)
LKGNKGP	0.0325* (0.0191)	0.0315* (0.0187)	0.0324* (0.0189)
LKGNLAB	-0.0210 (0.0372)	-0.0518 (0.0365)	-0.0307 (0.0370)
0.5*LKGPKGP	0.0206*** (0.0078)	0.0219*** (0.0079)	0.0208*** (0.0078)
LKGPLAB	-0.0047 (0.0243)	0.0101 (0.0232)	-0.0016 (0.0239)
0.5*LLABLAB	0.0086 (0.0500)	0.0297 (0.0491)	0.0154 (0.0497)

Table 5.6 (Continued)

LHA	0.1824 (0.4473)	0.2412 (0.4315)	0.1893 (0.4429)
0.5*LHALHA	0.0267 (0.0339)	0.0370 (0.0327)	0.0293 (0.0336)
LHAKGS	0.1172** (0.0556)	0.0982* (0.0543)	0.1119** (0.0552)
LHAKGN	-0.0596 (0.0451)	-0.0301 (0.0452)	-0.0523 (0.0451)
LHAKGP	-0.0877*** (0.0271)	-0.1082*** (0.0269)	-0.0926*** (0.0270)
LHALAB	0.1018 (0.0709)	0.0903 (0.0697)	0.1008 (0.0705)
DP	0.0103 (0.0277)	0.0372 (0.0286)	0.0143 (0.0282)
DV1	0.1719*** (0.0377)	0.1756*** (0.0371)	0.1741*** (0.0376)
DV2	0.1022* (0.533)	0.1379*** (0.0527)	0.1100** (0.0531)
DSS	0.0465** (0.0212)	0.0489*** (0.0191)	0.0478** (0.0204)
DR1	-0.0441 (0.0428)	-	-0.0454 (0.0503)
DR2	0.0240 (0.0541	-	0.0176 (0.0589)
DR3	-0.0017 (0.0569)	-	-0.0171 (0.0614)
DR4	0.0686 (0.0518)	-	0.0623 (0.0580)
DR5	0.1375*** (0.0547)	-	0.1256*** (0.0591)
σ_v^2	-	0.1004	0.1004
σ^2	-	-	0.1528

Table 5.6 (Continued)

σ_u^2	-	-	0.0087
$w=\sigma_v/\sigma$	-	-	0.8106
$\theta = 1 - w$	-	-	0.1894
E[u]	-	-	0.075
F-Statistic	287.82	138.97	10761.28
R^2	0.8934	0.7690	0.9968
N (individuals)	171	171	171
T (seasons)	6	6	6

Variable definition can be seen in chapter 4 and appendix 5.4
Figures in parentheses are standard deviations
*** statistically significant at α=0.01
** statistically significant at α=0.05
* statistically significant at α=0.10

The level of individual technical inefficiency is very close to that obtained from the Cobb-Douglas production frontier. The range of the individual level of technical efficiency is slightly wider than the range obtained in Cobb-Douglas case, that is 3.4% - 13.4%, with the mean 7.0%. The mean is 7.4% if equation (3.24a) is used. The rank of the individual technical inefficiency is not affected at all; it is exactly the same as the rank obtained from the Cobb-Douglas production frontier. Thus, the measure of individual technical inefficiency is invariant to the functional form of the production. The frequency distribution of farms based on technical inefficiency level is described in Table 5.7.

Table 5.7. Frequency Distribution of Farmers based on The Level of Technical Inefficiency from the Translog Production Frontier

Range of Technical Inefficiency	% farms ≤ 0.5 Ha	% farms > 0.5 Ha	% from total farms
≤ 5%	10.2	11.3	10.5
5% < u ≤ 10%	84.3	79.6	83.0
10% < u ≤ 15%	5.5	9.1	6.5
Total %	100	100	100
Total farms	127	44	171

5.3. Profit Function and Profit inefficiency

The direct estimation of profit function also uses three different estimators as in the case of the production function. The three statistical tests outlined in section 5.2.1, were repeated here. Statistical tests for both the FE specification (standard F test) and the RE specification (LM test) confirm the existence of individual specific effects representing individual levels of inefficiencies. The third test, the Mundlak test, justifies the use of RE specification, since the test could not reject the null hypothesis that no correlation exists between the individual effects and the included exogenous variables. This test, therefore, insures that the EGLS estimator is more efficient than the within estimator.

5.3.1. Cobb-Douglas Profit Frontier

The parameter estimates of the Cobb-Douglas normalized profit function are presented in Table 5.8. The computed F-value of OLS, within and EGLS is 162.0, 117.2, and 4053.6, respectively. The EGLS estimator provides a best fit compared to other estimators, with $R^2 = 0.9825$, compared to 0.6755 for OLS and 0.4458 for the within estimator. As in the case of production frontier, the parameter estimates of these three estimators are close enough to each other both in sign and magnitude. Again, this indicates that the random effect specification is valid. In the situation where the assumption of random effect is correct, the EGLS is more efficient than the within estimator. The following discussion will focus only on the EGLS estimator, although some comparisons to the others will also be made.

Except for labor wage, the coefficient estimates of the variable input prices have negative signs as expected, and are statistically significant at the 0.01 level for fertilizer price and at the 0.10 level for seed price. The regression coefficient of the normalized labor wage has a positive sign, which is unexpected, and is significant at the 0.10 significance level.

The profit elasticity with respect to the normalized seed price is -0.1331, meaning that a one percent increase in normalized (real) seed price will reduce the normalized profit by 0.13 percent. This relatively small elasticity is reasonable since seed input, in terms of its value, accounts for a very small percentage of the total value of output.

Table 5.8. Estimated Parameters of the Cobb-Douglas Normalized Profit Frontier

Independent Variables	Estimation Methods		
	OLS	Within	GLS
Constant	6.9280*** (0.1093)	-	6.9315*** (0.1184)
LPS	-0.1408* (0.0845)	-0.1173 (0.0818)	-0.1331* (0.0758)
LPF	-0.3670 *** (0.0785)	-0.3394*** (0.0673)	-0.3596*** (0.0759)
LWG	0.1621 (0.1049)	0.2817** (0.1891)	0.1937* (0.1021)
LHA	0.9905 *** (0.0250)	0.9194*** (0.0359)	0.9794*** (0.0272)
DP	0.1241** (0.0543)	0.1343** (0.0563)	0.1279** (0.0550)
DV1	0.2931*** (0.0786)	0.2133*** (0.0778)	0.2734*** (0.0785)
DV2	0.1793* (0.1094)	0.2657*** (0.1071)	0.2019** (0.1088)
DSS	0.0218 (0.0477)	0.0555 (0.0696)	0.0222 (0.0569)
DR1	-0.0179 (0.0863)	-	-0.0161 (0.1024)
DR2	0.2555** (0.1090)	-	0.2475** (0.1200)
DR3	0.2109** (0.1058)	-	0.1940** (0.1182)
DR4	0.1553 (0.1017)	-	0.1373 (0.1165)
DR5	0.4336*** (0.1046)	-	0.4212*** (0.1163)

Table 5.8 (Continued)

σ_v^2	-	0.4278	0.4278
σ^2	-	-	0.6572
σ_u^2	-	-	0.0382
$w=\sigma_v/\sigma$	-	-	0.8068
$\theta = 1 - w$	-	-	0.1932
E[u]	-	-	0.156
F-Statistic	162.0	117.2	4053.6
R^2	0.6755	0.4458	0.9825
N (individuals)	171	171	171
T (seasons)	6	6	6

Variable definition can be seen in chapter 4 or in appendix 5.4
Figures in parentheses are standard deviations
*** statistically significant at α=0.01
** statistically significant at α=0.05
* statistically significant at α=0.10

The profit elasticity with respect to the normalized fertilizer price is -0.3596, which indicates that a one percent increase in normalized price of fertilizer results in 0.36 percent reduction in normalized profit. Again the relatively low elasticity is due to the fact that the total value of fertilizer is only a minor percentage of the total profit or total value of output.

The sign of the labor wage coefficient is unexpected, and is rather difficult to interpret. However, the magnitude of the coefficient is very small, that is 0.1937 and significant at the 0.10 level. This can be interpreted that the variation of the normalized profit is weakly associated with the variation of the normalized labor wage. The explanation of this finding could be as follows. Labor is a dominant production input in Indonesian rice farming in general, and particularly in densely populated areas such as West Java. No substitutes are available for this input. In addition, economic considerations are not the only driving factor in hiring labor, and there may be many other factors which are more relevant in the rural situation. For example, it is very common for farm households to hire and to be hired by other households. Since money wage is only part of the total wage, (in some places like Wargabinangun it is only small part), this labor exchange situation occurs regardless the level of wage rate. This may explain why farmers are not so responsive to wage levels in their farm activities. Gunawan (1988), using the same data and cost function model, also found an unexpected (negative) sign for the labor wage coefficient.

The profit elasticity with respect to land is positive and statistically significant at the 0.01 significance level. The magnitude of 0.9794 of this coefficient tells us that one percent increase in farm size will result in 0.9794 percent increase in profit. In our case, this coefficient directly represents the returns to scale coefficient of the underlying production function. The within estimator of this coefficient is smaller, that is 0.9194, and is significant at the 0.01 significance level. The test related to scale coefficient will be discussed later.

The coefficient estimates of the dummy variables for pesticide and rice variety are all significant with positive signs, indicating that the use of pesticide and HYV increases the profit. The question is then why large numbers of farmers are not using HYV. It is very likely that economic factors are not the only ones farmers use to make decisions regarding the use of HYV. In Gunung Wangi (kabupaten Majalengka), for example, efforts to increase adoption of HYV have been unsuccessful, and almost all respondents in this village grew TV. Preference for growing TV could also be explained by the fact that most of the rice produced is for own-consumption, and since villagers find TVs taste better than HYV they prefer growing TV.

Unlike in the production function, the dummy variable for season is not significantly different from zero, indicating that season is not an explanatory variable for the profit variation. Profit is a function of price and total product. Price in the dry season sometimes is higher than in the wet season due to inelastic nature of rice supply function. The relatively higher price in the dry season may offset the reduction of total product, resulting in a non-significant difference between the wet and dry seasons profits.

Dummy variables for regions all have positive signs, although only three of them are significantly different from zero, indicating that, compared to Wargabinangun (as a control) the restricted profit earned by farmers in the other villages is higher. In light of individual village's accessibility factors described in chapter 3, this finding is reasonable, since these three villages have better product marketing channels due to better transportation facilities. The higher the price received, the higher the profit earned.

Before proceeding to the discussion of profit inefficiency, let us consider several advantages of Cobb-Douglas functional form, despite its weaknesses discussed later. One of its advantages, in addition to its simplicity, is that the dual-primal relationship is tractable, i.e., one can derive the production parameters from the profit (cost) function, or vice versa. Recalling equation (2.34), note that coefficient of the k^{th}

variable input price (α_k) equals $a_k/(1-r)$, where a_k is the k^{th} production parameter and $r = \Sigma_k a_k$. After some algreba we find that $a_k = -\alpha_k /(1 - r^*)$, where $r^* = \Sigma_k \alpha_k$. Similarly for the fixed input (land), we get that $b_h = \beta_h /(1 - r^*)$, where b and β are the production and profit elasticity with respect to farm size, respectively. Using these equations and the results in Table 5.7, for the EGLS estimator, we can obtain the indirect estimates of production elasticities, as presented in Table 5.9 below.

The result shows that, except for seed variable, the corresponding direct and indirect estimates are very different from each other. The indirect estimate of production elasticity with respect to labor is negative, indicating the production function is not well-behaved. This is because the profit function, from which indirect estimates are derived, is also not well-behaved, as marked by the positive sign of the labor wage.

Table 5.9. Direct and Indirect Production Elasticities of the Cobb-Douglas Production Function

Input	Direct Estimate[a]	Indirect Estimate[b]
Seed	0.1304	0.1025
Fertilizer	0.0944[c]	0.2768
Labor	0.2211	-0.1491
Farm Size	0.4676	0.7540

a) This is the EGLS estimator from Table (5.3)
b) Computed from the EGLS estimator in Table (5.7)
c) A simple average of LKGN and LKGP coefficients

Another advantage of Cobb-Douglas functional form is that the test of constant returns to scale for underlying production function can easily be performed. We know that $\beta_h = b_h/(1-r)$. If there is only one fixed input, as in our case, then this following relation holds:

$$\text{if } \beta = 1, \quad \text{then } \; b + r = 1$$

where $b + r$ is the returns to scale coefficient of the production function. Thus, the hypothesis of constant returns to scale can simply be tested by setting up the hypothesis whether or not β equals one. Following this procedure, we found that the null hypothesis of constant returns to scale for the OLS and EGLS estimators could not be rejected at the 0.10 level. Thus, the underlying production function is in the stage of constant returns to scale. This conclusion is consistent with the result of the direct production function estimation presented before. In contrast, the within estimator confirms that production function is in the stage of decreasing returns to scale, since the null hypothesis was rejected at the 0.10 level.

The rate of return to the fixed input in the Cobb-Douglas case is also readily available, equal to the partial derivative of the normalized profit function with respect to corresponding fixed input. In our case, the rate of return to land is equal to $\beta\pi/Z$, where β is the coefficient of farm size, while π/Z is the average normalized profit per hectare. Since constant returns to scale is confirmed, the rate of return to land therefore is exactly the profit per hectare. This result can be generalized for more than one fixed input.

The computation of output supply and input demand elasticities from the Cobb-Douglas profit function is also simple, compared to the translog profit function. The elasticities of output supply and input demand presented in Table 5.10 are estimated using equation (3.39) and (3.40) and the EGLS estimates in Table 5.8. More discussion about output supply and input demand elasticities will be covered in section 5.4.

Table 5.10. The Own- and Cross-price Elasticities and the Elasticities With Respect to Land of Rough Rice Supply and Variable Input Demand

	Price of				Farm
	Rice	Seed	Fertilizer	labor	size
Rice Supply	0.2290	-0.1331	-0.3596	-0.1937	0.9794
Demand for:					
Seed	1.2290	-1.1331	-0.3596	-0.1937	0.9794
Fertilizer	1.2290	-0.1331	-1.3596	-0.1937	0.9794
Labor	1.2290	-0.1331	-0.3596	-0.8063	0.9794

Let us now examine the level of profit inefficiency. The individual level of profit inefficiency and its individual rank are presented in appendix 5.7. The frequency distribution of farms based on technical inefficiency level is shown in Table 5.11. The computation, as in the case of technical inefficiency, follows the equation (3.69) of the Battese and Coelli (1986). The level of profit inefficiency ranges from 6.9% to 28.9% with the mean 13.8%. If the equation (3.24a) used, the mean is 18.4%. This indicates that on the average rice farmers are 13.8% profit inefficient. This percentage can also be interpreted as a percentage of profit loss. Table 5.11 also shows, as in the case of production function, that the level of profit inefficiency does not have any association with the farm size, meaning that small farms may or may not be more efficient than large farms. Therefore, as in the case of production frontier discussed above, it seems reasonable to interpret the mean of profit inefficiency level (13.8%), as a per-hectare profit loss due to inefficiency. Alternatively, we can reestimate a per-hectare profit frontier to get the same measure of profit inefficiency.

Table 5.11. Frequency Distribution of Farmers Based on the Level of Profit Inefficiency from the Cobb-Douglas Normalized Profit Function

Level of Profit Inefficiency	% from farms with		% from total farms
	≤ 0.5 Ha	> 0.5 Ha	
≤ 5%	0.0	0.0	0.0
5% < u ≤ 10%	11.8	6.8	10.5
10% < u ≤ 15%	58.3	63.6	59.6
15% < u ≤ 20%	24.4	20.5	23.4
20% < u ≤ 25%	3.9	6.8	4.7
25% < u ≤ 30%	1.6	2.3	1.8
> 30%	0.0	0.0	0.0
Total %	100	100	100
Total Farms	127	44	171

Given a figure of profit per hectare as presented in Table 5.1, and the annual harvested area of rice farms in West Java (1.74 million hectare), we can approximate the annual profit loss due to inefficiency (both technical and allocative inefficiencies). Using per-hectare profit figure in the dry season 1983 (Rp 326,000/ha), the per-hectare profit loss amounts to about Rp 45,000, and the total profit loss in rice farms in West Java amounts to about 78 billion Rupiahs annually (US$ 81 million, using exchange rate Rp970/US$ in 1983). Thus, the benefits of promoting increased efficiency in rice farm in Indonesia, particularly in West Java, appear to be extremely attractive.

5.3.2. Translog Profit Frontier

As in the case of translog production frontier, the estimated translog profit frontier also suffers from multicollinearity problem. While most coefficient estimates have correct signs, many are not statistically significant (Table 5.12).

There is no attempt to interpret the coefficient estimates individually, since they do not provide valuable information. Apart from the fact that some of them are not significant, the profit elasticities with respect to variable input prices are not constant in the case of translog profit function. The more meaningful interpretation would be associated with the measure of the elasticities of output supply and input demand, which is discussed later.

Table 5.12. Estimated parameters of the Translog Profit Function

Independent Variables	Estimation Methods		
	OLS	Within	GLS
Constant	6.6701***	-	6.6905***
	(0.1208)		(0.1298)
LPS	-0.1913	-0.1802	-0.1931
	(0.1807)	(0.1744)	(0.1785)
LPF	-0.6695***	-0.6372***	-0.6564***
	(0.0785)	(0.1498)	(0.1590)
LWG	-0.2972	-0.0797	-0.2171
	(0.2228)	(0.2033)	(0.2154)
0.5*LPSLPS	0.1906	0.2635	0.2201
	(0.1849)	(0.1782)	(0.1827)
LPSLPF	-0.4571*	-0.5434**	-0.4841**
	(0.2496)	(0.2332)	(0.2437)
LPSLWG	0.2767	0.0363	0.1950
	(0.3698)	(0.3456)	(0.3617)
0.5*LPFLPF	1.0926***	1.1027***	1.0984***
	(0.2350)	(0.2108)	(0.2262)
LPFLWG	-2.1349***	-2.0544***	-2.1114***
	(0.4321)	(0.3990)	(0.4207)
0.5*LWGLWG	0.1349	0.1188	0.1300
	(0.3155)	(0.2941)	(0.3081)
LHA	1.0305***	1.0189***	1.0381***
	(0.0602)	(0.0742)	(0.0631)
0.5*LHALHA	0.0398**	0.0529***	0.0448***
	(0.0157)	(0.0189)	(0.0166)
LHALPS	0.0426	0.0600	0.0454
	(0.0744)	(0.0745)	(0.0745)
LHALPF	-0.2828***	-0.2975***	-0.2879***
	(0.0744)	(0.0696)	(0.0720)
LHALWG	-0.2078**	-0.1310	-0.1778*
	(0.1061)	(0.0981)	(0.1033)

Table 5.12 (Continued)

DP	0.0656 (0.0542)	0.0648 (0.0571)	0.0659 (0.0553)
DV1	0.2869*** (0.0774)	0.2072*** (0.0765)	0.2617*** (0.0772)
DV2	0.1775* (0.1076)	0.2609*** (0.1052)	0.2034** (0.1069)
DSS	0.0005 (0.0464)	0.0045 (0.0696)	0.0022 (0.0578)
DR1	-0.0702 (0.0862)	-	-0.0726 (0.1052)
DR2	0.3623*** (0.1088)	-	0.3534*** (0.1218)
DR3	0.2895*** (0.1059)	-	0.2693** (0.1206)
DR4	0.3455*** (0.1058)	-	0.3275*** (0.1228)
DR5	0.5323*** (0.1074)	-	0.5191*** (0.1210)
σ_v^2	-	0.3924	0.3924
σ^2	-	-	0.6682
σ_u^2	-	-	0.0460
$w=\sigma_v/\sigma$	-	-	0.7664
$\theta = 1 - w$	-	-	0.2336
E[u]	-	-	0.171
F-Statistic	101.5	58.6	2341.8
R^2	0.6997	0.4458	0.9825
ADJ-R^2	0.6928	0.4420	0.9821
N (individuals)	171	171	171
T (seasons)	6	6	6

The coefficient of the dummy variables can be interpreted individually as before. The coefficient of the dummy varieties have the same signs and relatively the same magnitude compared to the Cobb-Douglas functional form. Similarly the coefficients of the dummy regions do not change in signs, the only difference being the coefficient of DR4 which previously was not significant now is highly significant.

The individual level of profit inefficiency, presented in appendix 5.8, is very close to the level obtained from Cobb-Douglas functional form. This is not surprising, and indeed it is expected. The level of profit inefficiency should be invariant from the functional form. The frequency distribution of farms based on the profit inefficiency level is described in Table 5.13.

5.4. Profit Maximizing Output Supply and Variable Input Demand Function

In general, the results of the direct estimation of the profit frontier outlined so far are not satisfactory. In the case of the Cobb-Douglas profit frontier, for example, the wage coefficient has the wrong sign which violates the behavioral assumption of profit maximization. The severe multicollinearity problem which apparently occurs in the estimation of translog profit frontier, makes the coefficient estimates meaningless since many of them, although having the correct signs, are not significantly different from zero. Thus, despite the fact that we were able to measure and interpret the individual level of profit inefficiency, we face a serious problem making meaningful interpretations of the estimated coefficients. The output supply and variable input demand functions derived from the above profit frontier will also be meaningless.

Table 5.13. Frequency Distribution of Farmers Based on the Level of Profit Inefficiency from the Translog Normalized Profit Frontier

Level of Profit Inefficiency	% From Farms with		% From Total Farms
	≤ 0.5 Ha	> 0.5 Ha	
≤ 5%	0.0	0.0	0.0
5% < u ≤ 10%	7.1	4.5	6.4
10% < u ≤ 15%	53.5	54.6	53.8
15% < u ≤ 20%	28.4	25.0	27.5
20% < u ≤ 25%	8.7	9.1	8.8
25% < u ≤ 30%	1.6	6.8	2.9
> 30%	0.8	0.0	0.6
Total %	100	100	100
Total Farms	127	44	171

The coefficient estimates presented so far are obtained from a single equation estimation procedure, that is by direct estimation of the profit function with no restrictions imposed on these estimates. Notice that, as discussed in chapter 3 section 3.4, some of the profit frontier parameters (i.e the parameters of variable factors of production), can alternatively be estimated from a set of factor demand (factor share) equations. Under the hypothesis of profit maximizing and price taking behavior on the part of farmers, the parameters from the factor share equations must be equal to the corresponding parameters in the profit function. Yotopoulos and Lau (1979) explore this equality property as a basis for testing the hypothesis of profit maximization, and simultaneously estimating the profit function and factor share functions. It may also be desirable to maintain the hypothesis of profit maximization as part of model specification. The output supply and input demand functions derived from this model should be referred to as profit maximizing output supply and input demand functions.

Given the facts that (i) EGLS estimators of the slope parameters, in the above single equation case, are very close to the OLS estimators of corresponding slope parameters, (ii) the complexity in estimating the SUR type for a random effect model, (iii) the unavailability of a statistical package to handle such model, and (iv) limited time available, it is desirable to approximate the slope parameters by simply running joint generalized least squares to the system equation of the pooled data. In this case we turn back to the non-frontier type of functions, rather than frontier function previously estimated. Since the slope parameters are more relevant in deriving output supply and input demand functions, it seems reasonable to use the average function as an approximation of the frontier function.

System equations of Cobb-Douglas profit function (equation 4.5) and system equations of translog profit function (equation 4.6), are estimated using the Zellner's SUR estimation method. In this analysis the "exact" profit maximizing hypotheses is maintained, by imposing equality restrictions of the parameters in profit function with the corresponding parameters in factor share equations. In the case of the translog profit function, this hypothesis also implies a symmetry restriction.

However, as mentioned before, there is a tradeoff in making the decision to impose restrictions. The main advantage for maintaining certain hypotheses by imposing restrictions is that the efficiency of the estimator of the parameters can be increased, whether or not the restrictions are correct. The main disadvantage is that the parameter estimate is biased if the restrictions are in fact incorrect. Consequently, we are faced with a decision whether to use unbiased estimator that has larger variance or the biased restricted estimators that has smaller variance. In our case, the restriction of profit maximization is considered to be reasonably correct, since this behavioral assumption is intuitively and theoretically acceptable.

The restricted parameter estimates of the Cobb-Douglas profit function are presented in Table 5.14. All the input price coefficients are significant at the one percent significance level and have correct signs. The result indicates that a one percent increase in prices of seed and fertilizer and in labor wage will reduce profit by 0.031, 0.1932 and 0.6007 percent, respectively.

The coefficient estimates of dummy variables are very close in magnitude to the corresponding coefficient estimates in the case of single equation estimators previously presented (Table 5.8), and except for the dummy variable of region one (DR1) they all have the same sign. Thus, all conclusions related to the dummy variables are the same as those previously made. For example, the total profit of farms with HYV and MV are significantly greater than the profit of the TV rice farms.

Table 5.15 describes the restricted parameter estimates of the translog profit function. Unlike the Cobb-Douglas function, the regression coefficients of the translog function, except those related to the dummy variables, are not readily interpreted. The profit elasticities with respect to variable input prices and quantity of fixed inputs are not

Table 5.14. Estimated Parameters of the Cobb-Douglas Normalized Profit Function Using Seemingly Unrelated Regression Estimation Method

Independent Variables	Profit Function	Share to Profit		
		Seed	Fertilizer	Labor
Intercept	7.0441*** (0.0694)	-0.0318*** (0.0028)	-0.1932*** (0.0113)	-0.6007*** (0.0373)
LPS	-0.0318*** (0.0028)	-	-	-
LPF	-0.1932*** (0.0113)	-	-	-
LWG	-0.6007*** (0.0373)	-	-	-
LHA	0.9547*** (0.0168)	-	-	-
DP	0.1599*** (0.0363)	-	-	-
DV1	0.3236*** (0.0507)	-	-	-
DV2	0.2753*** (0.0732)	-	-	-
DR1	-0.1382** (0.0583)	-	-	-
DR2	-0.0457 (0.0695)	-	-	-
DR3	0.0839 (0.0691)	-	-	-
DR4	0.1051* (0.0678)	-	-	-
DR5	0.2751*** (0.0687)	-	-	-

Variable Definition can be seen in chapter 4 or in appendix 5.4
*, **, and *** are difined as in the previous Tables.

Table 5.15. Estimated Parameters of the Translog Normalized Profit Function Using Seemingly Unrelated Regression Method

Independent Variables	Profit Function	Share to Profit		
		Seed	Fertilizer	Labor
Intercept	6.9888*** (0.0721)	-0.0360*** (0.0053)	-0.3148*** (0.0206)	-1.0465*** (0.0698)
LPS	-0.0360*** (0.0053)	-0.0591*** (0.0074)	-0.0208*** (0.0072)	-0.0338*** (0.0103)
LPF	-0.3148*** (0.0206)	-0.0208*** (0.0072)	-0.2082*** (0.0271)	-0.2930*** (0.0364)
LWG	-1.0465*** (0.0698)	-0.0338*** (0.0103)	-0.2930*** (0.0364)	-1.5378*** (0.1035)
0.5*LPSLPS	-0.0591*** (0.0074)	-	-	-
LPSLPF	-0.0208*** (0.0072)	-	-	-
LPSLWG	-0.0338*** (0.0103)	-	-	-
0.5*LPFLPF	-0.2082*** (0.0271)	-	-	-
LPFLWG	-0.2930*** (0.0364)	-	-	-
0.5*LWGLWG	-1.5378*** (0.1035)	-	-	-
LHA	1.0274*** (0.0368)	0.0024 (0.0028)	0.0120 (0.0114)	0.0395 (0.0378)
0.5*LHALHA	0.0253** (0.0103)	-	-	-
LHALPS	0.0024 (0.0028)	-	-	-
LHALPF	-0.0120 (0.0114)	-	-	-

Table 5.15 (Continued)

LHALWG	0.0395 (0.0378)	-	-	-
DP	0.1283*** (0.0347)	-	-	-
DV1	0.3511*** (0.0486)	-	-	-
DV2	0.2872*** (0.0698)	-	-	-
DR1	-0.1072* (0.0570)	-	-	-
DR2	0.1321** (0.0676)	-	-	-
DR3	0.1540** (0.0663)	-	-	-
DR4	0.2093*** (0.0654)	-	-	-
DR5	0.3694*** (0.0659)	-	-	-

Variable Definition can be seen in chapter 4 or in appendix 5.4
Figures in parentheses are standard deviations
*** statistically significant at α=0.01
** statistically significant at α=0.05
* statistically significant at α=0.10

constant. A common practice is to estimate these elasticities for average levels of variable input prices and fixed input quantities.

The magnitudes of the coefficient estimates of the price variables are very different from the corresponding estimates in the case of single equation estimators previously described (Table 5.12), even though some have the same signs. Similarities, however, hold for the coefficient estimates of the first order term of farm size and the coefficient estimates of the dummy variables.

We now come to the estimation and evaluation of the profit maximizing input demand and output supply elasticities. The own- and cross-price elasticities as well as the elasticities with respect to farm size of the output supply and input demand are estimated using equations (3.39) and (3.40) for the Cobb-Douglas profit function, and equations (3.45 - 3.48) and equation (3.51 - 3.53) for the translog profit function, described in chapter 3. The means of factor shares to restricted profit for seed, fertilizer and labor are 0.063, 0.386 and 1.125, respectively. The mean (over time) of the deflated prices in Table 5.2 are used in the computation. The results are presented in Table 5.16.

The translog functional form is superior to the Cobb-Douglas form in the measures of input demand and output supply elasticities. The former gives more reasonable elasticity figures than the latter. In the Cobb-Douglas case, for example, the impact across variable input demand functions for a given change in any of the exogenous variables is symmetry. This is due to the well-known property of constant unitary elasticity of substitution among all input pairs for Cobb-Douglas function. This is of course very unreasonable, unless only two production inputs are involved. The impact of a similar change in the case of translog function, on the other hand, varies across input demand equations, which is very consistent with *a priori* theoretical expectations. In the Cobb-Douglas case, moreover, the own-price elasticities for the well-behaved profit function, are definitely greater than one in absolute values, which are of course difficult to defend theoretically and empirically.

Table 5.16. The Own- and Cross-price Elasticities and the Elasticities with Respect to Land of the Rough-Rice Supply and Variable Input Demands.

	Price of:				Farm
	Rice	Seed	Fertilizer	Labor	Size
Cobb-Douglas Function					
Rice Supply	0.8257	-0.0318	-0.1932	-0.6007	0.9545
Demand for:					
Seed	1.8257	-1.0318	-0.1932	-0.6007	0.9545
Fertilizer	1.8257	-0.0318	-1.1932	-0.6007	0.9545
Labor	1.8257	-0.0318	-0.1932	-1.6007	0.9545
Translog Function					
Rice Supply	0.6026	-0.0189	-0.1832	-0.4006	1.2128
Demand for:					
Seed	0.7692	-0.1265	-0.0558	-0.5885	1.1957
Fertilizer	1.2217	-0.0091	-0.8467	-0.3659	1.2027
Labor	0.9166	-0.0330	-0.1256	-0.7581	1.1987

In general, the elasticity estimates from Cobb-Douglas profit function are much greater than corresponding estimates from the translog profit function, except for the elasticity with respect to fixed input (farm size). Negative cross-price elasticities from these two functional forms are consistent with theoretical expectation, which indicates a complementary nature of the production inputs. Positive own-price elasticities are consistent with the behavioral assumption of profit maximization.

The following discussion covers only the estimates from translog profit function. The own-price elasticity of rice supply is 0.6026, which is inelastic. This figure indicates that a one percent increase in price of rough rice, ceteris paribus, will increase rice supply by 0.6026 percent. The cross-price elasticities of rice supply with respect to prices of seed, fertilizer and labor wage are -0.0189, -0.1832 and -0.4006, respectively. Thus the own-price elasticity of output supply is more elastic than cross-price elasticities of output supply with respect to variable input prices. This always be the case for the well-behaved profit function, where the own-price elasticity of the output supply has to be equal to the summation of the cross-price elasticities (in absolute terms) of the corresponding output supply with respect to variable input prices.

The significant difference (in absolute terms) between the own-price elasticity of rice supply (0.6026) and the cross-price elasticity of rice supply with respect to fertilizer (-0.1832) roughly indicates that if increasing total rice production is the government's primary concern, the rice price support policy will likely be more effective than fertilizer subsidy policy. This because a one percent increase in the price of rice will increase the rice supply by 0.6026 percent, while a one percent reduction (subsidy) in the fertilizer price will increase the rice supply by only 0.11832 percent. Note, however, that the former involves movement along the supply curve while the latter involves a shift of the supply curve.

The own-price elasticities of demand for seed, fertilizer and labor are -0.1265, -0.8467 and -0.7581, respectively. The cross-price elasticity of demand for labor with respect to output price is much greater in absolute terms than corresponding elasticity with respect to fertilizer price. This implies that price support policy will likely be more effective in promoting agricultural employment than the fertilizer price subsidy. This because a one percent increase in rice price will increase labor demand by 0.9166 percent, while a one percent reduction in fertilizer price will increase labor demand by only 0.1256 percent.

The own-price elasticities of demand for seed, fertilizer and labor are -0.1265, -0.8467 and -0.7581, respectively. A one percent decrease in the prices of seed, fertilizer and labor wage, other things being constant, will increase the demands for seed, fertilizer and labor by 0.1265, 0.8467 and 0.7581 percent, respectively.

Table 5.16 shows that the cross-price elasticities of labor demand with respect to the prices of rice, seed, and fertilizer are 0.9166, -0.0330, and -0.1256, respectively. In absolute terms, the cross-price elasticity of labor demand with respect to rice price is much greater than corresponding elasticity with respect to fertilizer price. Again, with regard to the policy options in question, this roughly indicates that price support policy will likely be more effective in promoting agricultural employment than the fertilizer price subsidy. This because a one percent increase in rice price will increase labor demand by 0.9166 percent, while a one percent reduction in fertilizer price will increase labor demand by only 0.1256 percent.

The elasticity of output supply with respect to land is 1.2128. Lau, Lin and Yotopoulos (1979) pointed out that this figure reflects the _mutatis mutandis_ effect of a change in the quantity of land, allowing the farm to adjust its output and variable inputs optimally. Hence, this elasticity is not comparable to the production elasticity of land, which reflects the *ceteris paribus* effects of a change in the size of land, holding the quantities of variable inputs constant. The *mutatis mutandis* effect is greater than the *ceteris paribus* effect, and in fact was confirmed in this analysis.

Table 5.17 presents the indirect estimates of the Cobb-Douglas production elasticities using the results in Table 5.14. The table shows that, except for the seed variable, the corresponding direct and indirect estimates are relatively close to each other. The indirect estimates in this table appear more reasonable compared to the corresponding indirect estimates presented in Table 5.9.

Table 5.17. Direct and Indirect Elasticities of Cobb-Douglas Production Function

Input	Direct Estimate[a]	Indirect Estimate
Seed	0.1304	0.0174
Fertilizer	0.0944[b]	0.1058
Labor	0.2211	0.3290
Farm Size	0.4676	0.5229

a) This is the EGLS estimator from table (5.3)
b) A simple average of LKGN and LKGP coefficients

5.5. Adoption of New Rice Varieties

Using a multinomial logit model, this study attempted to identify the determinants of the farmers' decisions in choosing rice varieties. This objective is motivated by the fact that there were many farmers in the sample still growing TV, despite the fact that HYVs have long been promoted by the government. With regard to rice varieties, farmers face three alternatives: to grow TVs, HYVs, or both. The maximum likelihood estimation method was used to estimate the model on the pooled data (1026 observations).

The coefficient estimates and the standard deviations of the model are presented in Table 5.18. The negative coefficient of TV price indicates that any increase in TV price will reduce the probability of farmers growing HYV relative to TV. However, the statistically non significant of this coefficient, which is unexpected, indicates that TV price is not an important determinant in farmers' decisions on adopting HYV.

The coefficient of HYV price is positive and is statistically significant at the 0.01 significance level, indicating that any increase in HYV price will likely increase the probability of farmers growing HYV relative to TV. This finding is consistent with theoretical expectation of producer behavior. A policy implication of this result is that adoption of new technology (HYV) can be accelerated by providing sufficient incentives for farmers, for instance by increasing the price of HYV.

The price of fertilizer has a negative effect on the probability of farmers choosing HYV relative to TV, and is statistically significant at the 0.05 level. This indicates that an increase in fertilizer price will discourage farmers to grow HYV. This is consistent with the fact that HYV rice is more responsive to fertilizer application, as discussed in previous sections; an increase in fertilizer price will therefore reduce fertilizer application and in turn discourages farmers from growing HYV.

Table 5.18. Estimated Coefficients of the Multinomial Logit Model

Independent Variables	Dependent Variables		
	$\ln(P_2/P_1)$	$\ln(P_3/P_1)$	$\ln(P_3/P_2)$
Constant	0.5964 (0.8913)	-5.8011 (1.8158)	-6.3975 (2.1425)
PTV	-0.0018 (0.0061)	0.0056 (0.0120)	0.0074 (0.0181)
PHYV	0.0376*** (0.0100)	0.0041 (0.0193)	-0.0335 (0.0292)
PF	-0.0366** (0.0136)	0.0220 (0.0270)	0.0586 (0.0405)
WAGE	-0.0094* (0.0051)	0.00003 (0.0094)	0.0094 (0.0145)
HA	1.0265*** (0.1728)	1.1712*** (0.2317)	0.1447 (0.3558)

Variable definition can be found in chapter 4 and in appendix 5.4
Figures in parenthesis are standard deviations.
*** statistically significant at α=0.01
** statistically significant at α=0.05
* statistically significant at α=0.10

Labor wage has a negative effect on farmers' decision to grow HYV relative to TV and is statistically significant at the 0.1 level; thus an increase in labor wage will discourage farmers from using HYV relative to TV. This could be explained by the fact that (even though the mean of the total labor use indicates no difference between HYV and TV), some crop management activities of the HYVs, especially weeding, are very labor intensive. It is well known that physical characteristics of HYV (which is much shorter in the height) is inferior compared to TV in terms of its ability to compete with weeds.

Farm size positively affects the probability of using HYV relative to TV, and is statistically significant at the 0.01 significance level, indicating that larger farmers, other things being equal, are more likely to grow HYV. This is consistent with the notion that large farmers are commonly more responsive to new technologies. Sayogyo and Collier (1973), as cited in Gunawan (1988), using simple frequency distribution, found that the percentage of HYV adopters are much higher in the large farmer group compared to the small farmer group. The same conclusion was also made by Gunawan (1988).

Coefficient regressions for the probability of farmers growing MV relative to TV are not statistically significant, with the exception of the intercept and land coefficient. Growing MV is a compromise choice, and is a typical strategy to minimize risks, before totally adopting HYV. Again, large farmers are more likely to grow MV relative to TV, other things being equal.

Using equation (3.71) and (3.72) we can calculate the probability of each choice evaluated at the sample means for each explanatory variable, as presented in Table 5.19. Ignoring the non-significant coefficients, the probability of farmers with TV, HYV and MV are 0.5287, 0.4697 and 0.0016, respectively. These figures are significantly different from the varietal frequency distribution of the sample which are 0.6657, 0.2865 and 0.0478, respectively.

The coefficient estimates presented in Table 5.18 do not represent a percentage change in probability for a percentage change in explanatory variables, thus they are not typical elasticity measures (as in the case of linear probability model). Using the procedure described in appendix (3.1), we can derive the response elasticities of the probability of particular event with respect to changes in the explanatory variables, as presented in Table 5.20. Note that the calculation is carried out by setting the non-significant coefficients of Table 5.18 to zero.

Table 5.19. Mean Probabilities of Varietal Choice

Varietal Choice	Probabilities derived from	
	sample distribution	Multinomial logit
TV	0.6657	0.5287
HYV	0.2865	0.4697
MV	0.0478	0.0016

The interpretation of the elasticity figures is straight forward, and it is much simpler than the interpretation previously made based on figures on Table 5.18. The conclusion made, however, is consistent. A one percent increase in HYV price (ceteris paribus) will, on the one hand, reduce the probabilities for growing TV and MV by 5.19 percent and 1.45 percent, respectively, and on the other hand will increase the probability for growing HYV by 1.64 percent.

A one percent increase in the price of fertilizer will increase the probabilities for choosing TV and MV by 4.87 percent and 1.36 percent, respectively, but reduce the probability for choosing HYV by 1.54 percent. Similarly, a one percent increase in labor wage will result in, respectively, 1.27 percent and 0.36 percent increase in the probabilities for growing TV and MV, but it will result in 0.40 percent reduction in the probability for growing HYV. Finally, a one percent increase in farm size will, on the one hand, increase the probability of farmer choosing HYV and MV by 0.23 percent and 0.30 percent, and will on the other hand reduce the probability of farmer choosing TV by 0.75 percent.

Table 5.20. Elasticities Derived from The Multinomial Logit Model.

Independent Variables	P_1	P_2	P_3
PTV	0.0000	0.0000	0.0000
PHYV	-5.1958	1.6395	-1.4523
PF	4.8686	-1.5363	1.3608
WAGE	1.2704	-0.4009	0.3551
HA	-0.7474	0.2341	0.2966

Assessing these results for their policy implications, one can conclude that providing sufficient incentives is necessary if the adoption of HYV is an important priority. These incentives can be in the forms of reasonable input and output prices. This finding supports the notion of the induced innovation hypothesis that economic variables, including prices of inputs and output among others, are the main factors affecting the behavior of farmers in the adoption of new technologies. Thus, improved price support policy which allows the price of rice to gradually approach the real market price would appear to be a reasonable incentive to encourage farmers to adopt new HYVs.

Of course there are many other factors, particularly non-economic factors, which may significantly influence farmers' decisions in choosing variety. It was reported that the significant rice damage due to brown planthopper (BPH) attack in 1979/80 induced farmers in West Java and other areas to adopt new HYV which was promoted to be more resistant to BPH biotype 1 and 2. The development and diffusion of rice varieties in Indonesia is well-documented in the article of Bernsten et al. (1982). To date, it is not uncommon that farmers are obligated to adopt new BPH resistant varieties as part of pest (insect) control strategy promoted by the government.

5.6. Policy Evaluation: Rice Price Support and Fertilizer Subsidy

As described in chapter 2, increasing rice production and promoting employment in rural areas are two primary goals in agricultural development in Indonesia. To attain these goals, the Indonesian government subsidizes fertilizers and other production inputs but controls the price of rough rice. The domestic fertilizer prices are set well below their import parity prices (appendix 2.5). Moreover, the government maintains nominal fertilizer prices constant for several periods of time (appendix 2.1). As a result, the real (deflated) prices of fertilizers have decreased over time.

Since 1971 the government has implemented floor and ceiling prices of rice. The floor price is set high enough to stimulate domestic production, while the ceiling price is set low enough to provide affordable rice to consumers and to contain the rate of inflation. The floor price is determined on the basis of an incremental benefit-cost ratio which results from farmer's participation in the BIMAS program. Since the rate of increase in the nominal price of rice is usually below the general rate of inflation, the real (deflated) price of rice has been deteriorating.

Since pricing policies for both fertilizer and rice involve government's budget or subsidies, the question is then which subsidy should be reduced in light of the recent government budgetary constraints. Note that, as mentioned in chapter 2, the current government's policy concern is to phase out all kinds of subsidies. The question can also be raised differently as choosing the policy which can best achieve the specified policy goals at least cost to the government.

The estimates of own- and cross-price elasticities presented above can be used to roughly evaluate the impact of the price support and fertilizer subsidy policies with respect to the above two policy goals. Recall, for example, that the cross-price elasticities of rice supply with respect to variable input indicate the percentage change of the rice supply due to a one percent change in any input prices. These figures, however, do not provide any information about which one of these two policies is more desirable, neither in terms producer and consumer welfare nor government budget. Table 5.21 illustrates the likely performance of these two policies in terms of increasing rice production and rural employment. This table shows that the price support policy should be more effective than fertilizer subsidy policy in attaining the objectives of increasing rice production and rural employment. The estimates from both Cobb-Douglas and Translog functional forms consistently confirm this conclusion.

Table 5.21. The Impact of Rice Price Support and Fertilizer Subsidy Policies

Policy Scenario	% Effects on			
	Seed Use	Fertilizer Use	Labor Use	Rice Production
<u>Cobb-Douglas Function</u>				
1% subsidy in fertilizer price	0.1932	1.1932	0.1932	0.1932
1% support (increase) in rice price	1.8257	1.8257	1.8257	0.8257
<u>Translog Function</u>				
1% subsidy in fertilizer price	0.0558	0.8467	0.1256	0.1832
1% support (increase) in rice price	0.7692	1.2217	0.9166	0.6026

Let us now evaluate these two policy alternatives by using the proposed procedure described in chapter 4. The procedure is based on the idea of comparing the two policies in terms of the additional government costs in generating an additional unit of rice and employment opportunity. The smaller the costs, the more desirable is the policy. The results of the calculation are presented in Table 5.22, while the detail is presented in appendix 5.9. The elasticity estimates from Cobb-Douglas and translog functional forms are used in the evaluation, and as expected, they both give consistent conclusions.

Table 5.22. Government's Additional Cost for an Additional Unit of Rough Rice and Rural Employment

Policy Options	Based on Elasticity Estimates	
	Cobb-Douglas	Translog
Rice Price Support (1%):		
Cost/Unit Rice (Rp/Kg)	12.26	16.80
Cost/Unit Employ.(Rp/Manday)	356.84	321.45
Fertilizer Subsidy (1%):		
Cost/Unit Rice (Rp/Kg)	27.50	29.03
Cost/Unit Employ.(Rp/Manday)	801.12	1232.30

Table 5.22 shows that if the specified price support policy is implemented, the government's additional cost for an additional unit (kg) of rice will be Rp 12.26 if estimated elasticities from Cobb-Douglas function are used, and Rp 16.80 if the translog estimates are used. These figures are much smaller compared to the corresponding figures derived from the implementation of the fertilizer subsidy policy, which are Rp 27.5 and Rp 29.03, respectively. Thus, as previously indicated, the price support policy is less costly than the fertilizer subsidy policy for as increasing rice production.

Similarly the price support policy provides much cheaper way to promote rural employment compared to the fertilizer subsidy policy. This because the government's additional cost to generate one manday of employment is only Rp 356.84 if the Cobb-Douglas estimates are used and Rp 321.45 if the translog estimates are used, compared to the costs derived from the implementation of the fertilizer subsidy policy, which are Rp 801.12 and Rp 1232.30, respectively.

Moreover, price support policy may also have positive direct consequences for supporting diversified-food-consumption program in Indonesia to reduce people's dependency on rice. Setting the price of rice too low as is currently done may (i) induce further dependencies on rice since it is affordable for all income levels, (ii) accelerate total rice demand due to population pressure, and (iii) turn Indonesia back to the largest rice importing country as. Thus, the implementation of improved price support policy, while at the same time gradually reducing input subsidies, could be one of the strategies to maintain rice self-sufficiency goal in the future.

The conclusion made here, however, contradicts the conclusion made in Barker and Hayami (1976). Using rice in the Philippines as case and a benefit-cost analysis as the main tool of analysis, they attempted to evaluate rice support and input subsidy as policy alternatives to achieve food self-sufficiency in developing countries. The benefits and costs associated with these alternative programs and their income distribution effects are estimated and compared with the case of no programs. They concluded that in terms of the social benefit/cost ratio, fertilizer subsidy is more efficient than rice price support.

Which one of these two policies is more desirable is debatable and the conclusion made is highly dependent on the country's situation. Since the results of this study support price support policy, it would be worthwhile to consider the opposing arguments in order to see what likely problems created by this policy; problems particularly related to consumer and producer welfare, which are not incorporated in the evaluation procedure of this study.

To date, there are two opposing arguments regarding the price support policy. Economists generally accept that farmers are responsive to price incentives and that production will tend to increase when rewards are greater. Yet even the most ardent advocates of higher prices for agricultural producers would admit that many other things are necessary to call forth the extra supply. Among these is the removal of physical, social, and administrative barriers to increased supply (Streeten, 1987). Institutional arrangements which ensure that the benefits of the higher prices accrue to the farmers and not to monopolistic private middlemen or to inefficient public marketing authorities must be in place. New technology must always be available so that incentives of higher prices can significantly accelerate the growth of rice production.

Proponents differ on whether raising prices without these other measures is better than nothing or whether raising prices, by itself, is futile or even counterproductive. The critics commonly point to cases where the introduction of higher supply prices without an appropriate scale-neutral technology or without the appropriate institutions has accelerated the transfer of land from small to large farmers and violated equity and poverty alleviation objectives (Streeten, 1987). If the productivity per hectare on the small farms was greater than on large farms, total output fell.

Increased agricultural prices will in the long run lead to lower food prices than would otherwise have prevailed; the improved short-term incentives to invest, innovate, and adopt technical change will bring about a downward shift of the whole supply curve. This is perfectly possible and appears to have happened, but, according to Streeten (1987), the following two qualifications are necessary. First, this very much depends on the initial land distribution and tenure system, on access to agricultural inputs, on institutions, on infrastructure, and on information. In societies with unequally distributed power and wealth, an increase in the food price may make rich richer by leading to transfers of land without leading to downward shift of the supply curve. A second qualification relates to the period of transition, in terms of the impact of food price increases on the impoverished food consumers. A rise in price of rice, for example, raises the real incomes of food producers and lowers, in the short run, the real income of the food consumers, since in the short run the supply of rice does not rise. In developing countries, such as Indonesia, there are many very poor people in both groups. In the medium and long run, the detrimental impact on the impoverished food consumers can be mitigated or offset by changing technology, increasing supply of food, increasing employment and perhaps reducing rural-urban migration which in turn increases urban income level. The very poor food consumer, however, may starve to death before the blessings of the medium and the long run materialize. Streeten identified three groups vulnerable to raising food prices: (i) landless laborers and deficit farmers, (ii) small surplus farmers, and (iii) the urban poor.

Streeten, furthermore, pointed out three different alternatives to protect the above vulnerable groups. One way to protect these groups in the short run is to increase the price gradually. Very large price increases might even have perverse effects on supply with producers choosing to increase leisure time rather than increasing production. An alternative way is to make subsidies as selective and targeted as possible by concentrating them either on vulnerable groups or on basic food staples consumed by the poor. A third way is to provide income subsidies to the poor.

The importance of remunerative food prices as supply incentives is not questioned, although price policies are but one of many policy instruments available to governments for expanding food production. In similar fashion, Pinstrup-Andersen (1987) argues that policies that attempt to strengthen incentives to expand food production through higher food prices may result in reduced real incomes and severe hardships for the poor, at least in the short run. Moreover, it is likely that the long-run effects are of little or no interest to the poor who are adversely affected in the short run, and uncertain future gains may be insufficient to compensate for immediate losses of the poor.

The impact of food price increases on those poor who derive their income from food production would be expected to be positive provided the price increase is reflected in higher farmgate prices. Higher prices would add to revenues obtained from marketable surpluses, and labor demand for rice production would be expected to increase. However, total demand for rural labor need not increase if the food price increases cause the substitution of less labor-intensive for more labor intensive commodities.

Recent research indicates that food price increases may be much less favorable for the rural poor than is often expected. Many of the rural poor do not derive a large share of their income from either wage labor in food production or from the sale of food, and a large proportion are net purchasers of food. A study in Thailand conducted by Trairatvorakul (1984), as cited by Pinstrup-Andersen (1987), shows that the rural poor would not benefit greatly from increased domestic rice prices. Even though many of the rural poor are rice producers, their marketable surplus is often small and large proportion are net buyers of rice. Trairatvorakul concludes that increasing rice prices would primarily benefit larger farmers and would create severe hardships among rural as well as urban poor.

Increasing output prices without technological change in production, improved input markets, and better rural infrastructure may have little impact on total supply, although the commodity mix may change. Furthermore, because of market imperfections, only a relatively small part of the price increase in the final market may be transmitted to the producers. Technological change that reduces unit cost plays a particularly important role because it facilitates expanded food supply at equal or lower prices and employment creation in rural areas. Institutional changes may be needed to assure that food price increases are transmitted to the producers. In particular, improving marketing efficiency is necessary to simultaneously realize both higher producer and lower consumer prices.

VI. SUMMARY AND RECOMMENDATION

The role of the agricultural sector in the Indonesian economy, although declining, is still dominant, not only in terms of its contribution to national income but particularly in terms of its substantial contribution to labor absorption. In 1985, the agricultural sector accounted for about 24 percent of the GDP, and 54 percent of the total employment. Within the sector, the farm food subsector has the greatest contribution. It is not surprising if a high development priority has been given to the agricultural sector, especially the farm food subsector.

In the past, the primary objective of agriculture policy was to achieve production targets to meet an ever-increasing demand for rice resulting from population pressures and increased households' income, and to promote employment opportunity in rural areas. Thus the policy target was very clear, that was to produce as much food as possible, regardless of what will be the problems after producing them. A great deal of effort and a large portion of the government budget were devoted to achieve the goals. Introduction of high yielding varieties of rice along with the rehabilitation, upgrading and expansion of irrigation system and provision of continuous supplies of subsidized inputs (fertilizers and pesticides) were, among others, the major contributors to the increase of rice production in Indonesia. Investment in transportation and other infrastructure was also undertaken as part of the extensive development strategies. All these efforts resulted in obvious benefits during the late of 1960s up to the late of 1970s when the rate of growth of rice was as high as 8% annually.

The elevated production, however, did not persist over the long run and the rate of growth of the rice production has been declining in recent years. During the period of 1982-1985, for instance, the growth rate of rice production was 5% per year, and it declined to only 1.3% during period of 1985-1987. Given a steady annual population growth rate of 2.3%, and the continuing decline of rice production, it will not be too surprising if Indonesia returns to its former role as the world biggest rice importing country in the near future.

The recent policy issue is a general movement towards a phasing out all subsidies. To date, subsidies are used as a major instrument in food price policies. Some productive inputs, such as fertilizers and pesticides, are highly subsidized in order to offset the production disinsentive effects of the rice subsidies to consumers. Recently, critics have questioned the ability of the Indonesian government to maintain the goal of long-run rice self-sufficiency, given the rapid growth of total rice demand in the one hand, and relatively stagnated growth of total rice production on the other hand. Some scientists consistently assert that Indonesia's success in achieving the goal is at the expense of efficiency.

This study aims to (i) generate and evaluate parameters of rice production system, especially those related to farm level efficiency, returns to scale, rice supply and demand for inputs, (ii) identify factors affecting farmers' decisions in the adoption of new rice varieties, and (ii) evaluate current agricultural policies, particularly price support and input subsidy policies.

6.1. Empirical Finding and Conclusion

6.1.1. Results of Descriptive Analysis

1. The average size of land cultivated with rice in the dry season is smaller than the average size in the wet season. This seasonal difference is statistically significant at 0.01 significance level. Risk averse behavior (e.e. avoiding drought risks) and the lack of irrigation water due to inappropriate irrigation systems, could be the main reasons for the seasonal difference in hectareage of rice.

2. The average yield per hectare is greater for the wet season than for the dry season. The result of analysis of variance verifies that seasonal difference in yield is statistically significant at 0.10 significance level.

3. The amount of seed used is relatively stable over time. The average figure does not show any consistent relationship between the amount of seed and season. The result of the analysis of variance, where the computed F-value is 0.92, supports the conclusion that there is no seasonal differences in the quantity of seed used.

4. The amount of fertilizer used per hectare tends to increase over time. On the average, farmers use more fertilizer in the wet season than in the dry season. The result of analysis of variance confirms the seasonal difference in fertilizer use, both for urea and phosphate, with computed F-statistic 3.78 (α=0.05) and 2.99 (α=0.08), respectively. This result indicates that seasonal differences in fertilizer application is more significant in urea than in TSP.

5. Seasonal difference in labor use is significant at 0.10 significance level. Hired labor is dominant, that is about 70-80% of the quantity of labor use per hectare is hired labor.

6. The average land of the HYV farmers is larger than the average land of the TV farmers, confirming the contention that large farmers are more responsive to new technology than small farmers. On the average, the HYV farmers use more urea than TV farmers, and as a result the HYV yield is significantly higher than the TV yield. The average quantities of seed, TSP and labor per hectare are not significantly different between these two groups. The results of the analysis of variance support all these conclusions.

6.1.2. Model Selection and Estimation methods

1. In a single equation estimation framework, the Cobb-Douglas functional form gives statistically more reliable parameter estimates than translog functional form. The possibility of high degree multicollinearity exists in the translog case, marked by large number of statistically non-significant parameter estimates while the computed F-statistic of the model is large.

2. Both statistical tests for fixed effect (FE) specification and random effect (RE) specification confirm the existence of individual specific effects representing the individual level of inefficiencies.

3. As far as the Cobb-Douglas functional form is concerned, the Mundlak test (standard F test) justifies the use of RE specification, since the test could not reject the null hypothesis of no correlation existing between the individual effects and the included exogenous variables. This test, therefore, ensures that the EGLS estimator is more efficient than the within estimator. The EGLS estimator in fact gives the best fit (i.e. the highest coefficient of multiple determination - R^2) for both the production and the profit frontiers.

4. The results show little difference in magnitude between the OLS, the within and the EGLS estimators. The sign of each parameter estimate of the EGLS estimator is exactly the same as the sign of the corresponding estimate of the within and the OLS estimators. In fact, the magnitude of the EGLS estimator lies in-between the magnitude of the other two estimators. This confirms that the RE model is correct.

5. The own- and cross-price elasticities of output supply and input demand were derived from a system of equations of the profit and variable input share functions using seemingly unrelated regression estimation framework. In this case we turn back to the usual non-frontier type of function. Profit maximization is part of the maintained hypothesis in the parameter estimation.

6. Compared to the translog profit function, the Cobb-Douglas profit function gives, in general, greater (in absolute terms) elasticity estimates of the output supply and derived input demand function. In the Cobb-Douglas case, due to the well-known property of unitary elasticity of substitution among all input pairs, the impact across variable input demand functions for a given change in any of the exogenous variables is symmetry. On the other hand, the impact of a similar change in the case of translog varies across input demand equations, which is very consistent with a priori theoretical expectation. In the Cobb-Douglas case, moreover, the own-price elasticities of input demand for the well-behaved profit function, are definitely greater than one in absolute terms. Thus due to these weaknesses, the Cobb-Douglas functional form is considered to be inferior despite its many advantages including its simplicity.

7. Despite the differences in magnitude of the elasticity estimates, the results of these two functional forms consistently support the

argument that price support policy is more effective in increasing production and promoting employment than fertilizer price subsidy.

6.1.3. Production Function

1. The dummy variable for season has a positive sign and is statistically significant at 0.05 significance level, indicating that the level of production for wet season is greater than that for the dry season. The lack of water availability during the dry season due to inappropriate irrigation facilities is the key reason for this seasonal yield difference, as reported in the survey.

2. The dummy variable for farm size (i.e. small or large farm category), is not significantly different from zero, indicating that there is no significant difference in the productivity level between small and large farms. In other words, small farms may or may not be more productive than large farms.

3. The dummy variables for varieties, HYV and MV, are statistically significant at 0.01 significant level, with positive signs. This strongly indicates that farms with HYV and MV produce more output than TV farms, which is consistent with *a priori* expectations.

4. The dummy variable for pesticide use is not significant, indicating no difference in production with or without pesticide use. It was reported that during survey periods no significant crop damage due to insect attack or plant diseases occurred in the study area.

5. There is no statistically significant difference in the level of production between regions. This is not surprising given the fact that BIMAS/INMAS program have been intensively implemented in nearly all of the West Java province, particularly in the regions covered in the survey

which are major rice production areas.

6. The production elasticities with respect to seed, labor, land, urea and phosphate fertilizer are 0.1304, 0.2211, 0.4676, 0.1110 and 0.0778, respectively, and are statistically significant at 0.01 significance level. Thus, a one percent increase in the amount of each of these inputs, ceteris paribus, will increase the level of production by that percentage amount, respectively. The production elasticity with respect to urea fertilizer is greater than the elasticity with respect to phosphate fertilizer. This finding could be used to support the argument for differentiating the prices of these two fertilizers, if the government's primary concern is to gradually reduce fertilizer subsidies. Up to now, however, the prices of these two are kept the same by the government.

7. Rice production in West Java is found to be in the stage of constant returns to scale, indicating that a one percent increase of all inputs will result in a corresponding one percent increase in the level of production.

8. The range of individual technical inefficiency is 3.4% - 12% with the mean 6.5%. These figures simply tell us that the rice farms in West Java are, on the average, 6.5% technically inefficient or 93.5% technically efficient. Using rice yield for the 1983 dry season (4003 kg/ha) and the figure of total annual harvested area in West Java (1.74 million hectare), the estimate of yield loss was 260 kg per hectare, and the total quantity of production loss would be about 0.45 million tons annually.

9. The individual level of technical inefficiency is invariant to the choice of functional form. Both the Cobb-douglas and the translog give approximately the same mean and range of this measure, and the individual rank based on the level of inefficiency is exactly the same.

10. This study confirms that farmers in the study area are not able to optimally allocate the production inputs. There is a tendency that farmers underutilize both seed and fertilizers, but overutilize labor.

6.1.4. Profit Function

1. The dummy variables for varieties, HYV and MV, of the profit function all have positive signs and are statistically significant, indicating that HYV and MV farmers are making more profits than the TV farmers. Interestingly, the majority of farmers in the study area were still using TV rice. Preference for growing TV could be justified given that (i) consumers prefer the taste of TV over HYV, and (ii) most of the rice produced is for own-consumption.

2. Unlike the production function case, the dummy variable for season is not significantly different from zero. The relatively higher rice price in the dry season (due to inelastic nature of rice supply function) may offset the reduction of total output, resulting in a nonsignificant difference between profit in the dry season and the wet season.

3. Dummy variables for regions all have positive signs, although only three of them are statistically significant, indicating that, compared to Wargabinangun (as a control), the profit earned by farmers in other regions is significantly higher. This finding is reasonable, since the other villages have relatively better product marketing channels due to better transportation facilities. The higher the price received, the higher the profit earned.

4. The individual profit inefficiency ranges from 6.9% to 28.9% with the mean 13.8%, indicating that on the average rice farms are 13.8% profit inefficient or 86.2% profit efficient. Thus, on the average, 13.8% of

profits are foregone due to inefficiency. The results also show that individual level of profit inefficiency does not have any association with individual farm size, meaning that large farms may or may not be more profit efficient than small farms. Using a per-hectare profit figure in the dry season 1983 (Rp 326,000/ha) and the total harvested areas in West Java per year (1.74 million hectare), a roughly estimate of per-hectare profit loss amounts to about Rp 45,000, while the total profit loss in West Java rice farms amounts to about Rp 78 billion annually, or about US$ 81 million at the 1983 exchange rate (Rp970/US$). Thus, the benefits of promoting increased efficiency in rice farms in Indonesia appear to be very attractive.

6.1.5. Output Supply and Derived Input Demand

1. In general, the elasticity estimates of output supply and input demand from the Cobb-Douglas Profit function are much greater than corresponding estimates from the translog profit function. The negative signs of cross-price elasticities from these two functional forms are consistent with theoretical expectation, indicating a complementary nature of production inputs. Similarly, positive signs of own-price elasticity of supply and negative sign of own-price elasticities of input demand are consistent with _a priori_ theoretical expectations of profit maximizing behavior.

2. The supply function of rough rice is found to be inelastic, as expected, with the own-price elasticity of 0.6026. This figure indicates that a one percent increase in the price of rough rice results in 0.6026 percent increase in rice supply. The cross-price elasticities of rice supply with respect to prices of seed, fertilizer and labor wage are -

0.0189, -0.1832 and -0.4006, respectively. Thus, the own-price elasticity is more elastic than cross-price elasticities of output supply with respect to input prices.

3. The own-price elasticities of demand for seed, fertilizer and labor are -0.1265, -0.8467 and -0.7581, respectively. The cross-price elasticities of fertilizer demand with respect to seed price, labor wage and rice price are -0.0091, -0.3659 and 1.2217, respectively. The cross-price elasticities of labor demand with respect to prices of seed, fertilizer and rough rice are, -0.0330, -0.1256, and 0.9166. Finally, the cross-price elasticities of seed demand with respect to fertilizer price, labor wage and rice price are -0.0558, -0.5885 and 0.7692, respectively.

4. The elasticity of output supply with respect to land (farm size) is 1.2128, indicating that a one percent increase in the size of land, *mutatis mutandis*, will result in 1.2128 percent increase in the quantity of output.

6.1.6. Multinomial Logit: Adoption of HYV

1. The price of HYV positively affects the probability of farmers growing HYV relative to TV, and was found statistically significant at the 0.01 significance level. The higher the price of HYV, other things being equal, the more likely farmer to grow HYV. This is consistent with theoretical expectation. Even though statistically insignificant, the price of TV negatively affects the probability of farmers growing HYV relative to TV, meaning that the higher the price of TV the less likely farmer to grow HYV.

2. The price of fertilizer has a negative effect on the probability of farmers choosing HYV relative to TV, and is statistically significant at

0.05 significance level, indicating that an increase in fertilizer price, other things constant, will discourage farmers from growing HYV. This is consistent with the fact that HYV rice is more responsive to fertilizer application. An increase in fertilizer price will therefore reduce fertilizer application and this in turn discourages farmers from growing HYV.

3. Similarly, labor wages negatively affect farmer decisions on grow HYV relative to TV, and is statistically significant at the 0.1 level, indicating that an increase in labor wages will reduce the probability of farmers using HYV relative to TV.

4. Farm size positively affects the probability of using HYV relative to TV, and is statistically significant at 0.01 significance level, indicating that larger farmers, other things being equal, are more likely to grow HYV. This is consistent with the notion that larger farmers are usually more responsive to new technologies.

5. All coefficient regressions of the probability of farmers growing MV relative to TV are not statistically significant, with the exception of the intercept and land coefficient. Large farmers are more likely to grow mixed varieties (MV) relative to TV, other things being equal. Growing MV is a likely compromise choice, is a typical strategy to minimize risks, before totally adopting HYV.

6. Ignoring the non-significant coefficients, the derived probability of farmers growing TV, HYV and MV are 0.5287, 0.4497 and 0.0016, respectively. These figures are different from the frequency distribution derived from the sample which are 0.6657, 0.2865 and 0.0478, respectively.

7. A one percent increase in HYV price (*ceteris paribus*) will, on the one hand, reduce the probabilities for growing TV and MV by 5.19 percent

and 1.45 percent, respectively, and on the other hand will increase the probability for growing HYV by 1.64 percent.

8. A one percent increase in the price of fertilizer will increase the probabilities for choosing TV and MV by 4.87 percent and 1.36 percent, respectively, but reduce the probability for choosing HYV by 1.54 percent.

9. Similarly, a one percent increase in labor wages will result in, respectively, 1.27 percent and 0.36 percent increase in the probabilities for growing TV and MV, but it will result in 0.40 percent reduction in the probability for growing HYV.

10. A one percent increase in farm size will, on the one hand, increase the probability of farmers growing HYV and MV by 0.23 percent and 0.30 percent, respectively, and will on the other hand reduce the probability of farmer growing TV by 0.75 percent.

11. Obviously there are many other factors, particularly non-economic factors, which may significantly influence farmers' decisions in choosing rice varieties. Brown planthopper (BPH) and other insect attacks were apparently important factors in inducing farmers in West Java and other areas to adopt new HYVs which are more resistant to BPH biotype 1 and 2.

6.1.7. Evaluation of Rice Price Support and Fertilizer Subsidy

1. The estimates of own- and cross-price elasticities can be used to roughly evaluate the impact of the price support and fertilizer subsidy policies with respect to the above two policy goals. These estimates, however, do not provide any information about which one of these two policies is more desirable, neither in terms producer and consumer welfare nor government budget.

2. The cross-price elasticity of demand for labor with respect to

output price is much greater in absolute terms than corresponding elasticity with respect to fertilizer price, implying that price support policy will likely be more effective in promoting agricultural employment than the fertilizer price subsidy. This because a one percent increase in rice price will increase labor demand by 0.9166 percent, while a one percent reduction in fertilizer price will increase labor demand by only 0.1256 percent.

3. In absolute terms, the cross-price elasticity of labor demand with respect to rice price is much greater than corresponding elasticity with respect to fertilizer price. Again, with regard to the policy options in question, this roughly indicates that price support policy will likely be more effective in promoting agricultural employment than the fertilizer price subsidy. This because a one percent increase in rice price will increase labor demand by 0.9166 percent, while a one percent reduction in fertilizer price will increase labor demand by only 0.1256 percent.

4. The results of price and subsidy policy evaluation indicate that rice price support is less costly than fertilizer subsidy policy in increasing total rice production and rural employment. If rice price support policy is implemented, the government's additional cost for an additional kilogram of rice will be Rp 12.26 if the Cobb-Douglas elasticity estimates are used, and Rp 16.80 if the translog estimates are used. These figures are much smaller compared to the corresponding figures derived from the implementation of the fertilizer subsidy policy, which are Rp 27.5 and Rp 29.03, respectively.

5. Similarly the price support policy provides much cheaper way to promote rural employment compared to the fertilizer subsidy policy. This because the government's additional cost to generate one manday of

employment is only Rp 356.84 if the Cobb-Douglas estimates are used and Rp 321.45 if the translog estimates are used, compared to the costs derived from the implementation of the fertilizer subsidy policy, which are Rp 801.12 and Rp 1232.30, respectively.

6.2. Policy Implication

This study confirms that a yield increasing technology is sill the best choice in the future, for the following reasons: (i) relatively small land holdings and land intensive nature of Indonesian rice farming in general, and West Java in particular, (ii) objective of increasing total rice production to meet accelerating growth for rice demand, and (iii) objective of increasing farmer's income. However, given the fact that varietal quality and taste are also important part of farmers' considerations in choosing varieties, efforts have to be directed to finding new HYVs with better taste and quality. Other criteria such as resistance levels to insect attacks and diseases, must also be considered.

Improving irrigation systems to control and guarantee optimal irrigation water availability throughout the year, appears essential and is confirmed by the results of this study. In the very near future, given government's budget limitations, attention should be given to the improvement of the existing irrigation systems, particularly those categorized as local or simple irrigation systems.

Farmers' skills, motivation and willingness are the key factors for making any policy succeed. Continuing efforts in improving extension services in order to motivate and improve farmer's management practices are important, particularly given the fact that the potential benefits of promoting increased efficiency both in terms of total rice production and total income are very high. To guarantee improvement in farmer's income, in addition to the improvement in yield through HYV and improved irrigation, the adoption of new rice technology will also require an improvement of other services (e.g., a more efficient supply of inputs and farm credit) and reasonable economic incentives for farmers. This study verifies that, despite the input production incentives they receive, farmer's real income is in fact deteriorating over time.

Assuming that the Cobb-Douglas production function used in this study properly represents the true response curve of the existing technology, the results confirm that the rice production is in the stage of constant returns to scale. If this is true, natural land consolidation which has gradually come into existence in some places, would not have any effect in increasing total rice production, despite some advantages related to post-harvest activities. Considering (i) direct consequences of land consolidation, e.g., increasing number of landless, and (ii) HYV is in fact not labor intensive technology, as verified in this study, attention must be given to the potential social problems which might occur in rural areas due to unemployment.

With regard to the government budget constraints and the objectives of increasing rice production and rural employment, this study verifies that price support policy is more desirable than fertilizer subsidy policy. The price support is less costly than fertilizer subsidy policy for attaining those objectives. Moreover, this policy will encourage farmers to adopt HYV and therefore to increase total rice production. Price support policy may also have positive direct consequences for supporting diversified-food-consumption program in Indonesia. Setting the price of rice too low as in the case now, may have further consequences as follows: (i) induces consumers to further dependent on rice since it is affordable for almost all income levels, (ii) accelerates the total rice demand due to population pressure, and (iii) eventually forces the country back to its former role as the world's largest rice importing country. Thus, the implementation of improved price support policy, coupled with a gradual reduction in input subsidies, may be one policy alternative to maintain the long-run rice self-sufficiency goal.

The short-run detrimental impact of the price support policy on poor rice consumers must be carefully considered. In the medium and long run, this detrimental impact may be offset by changing technology, increasing supply of rice and increasing employment opportunity in rural areas. The poor rice consumers, including landless laborers and deficit farmers, may starve to death before the blessings of the medium and the long run materialize. One way to protect these groups in the short run is to increase the price of rice gradually.

Increasing the price of rice without technological change in the rice production, improved input markets, and better rural infrastructure may have little impact on the total rice supply. Furthermore, because of market imperfections, only a relatively small part of the price increases may be transmitted to the rice producers. Institutional changes are needed to assure that price increases are transmitted to the producers. In particular, improving marketing efficiency is necessary to simultaneously realize both higher producer and lower consumer prices.

5.3. Recommendation for Further Research

This study was not able to identify factors affecting individual level of technical as well as profit inefficiency, due to lack of data availability. Socioeconomic factors such as education, farming experience, tenancy, off-farm employment, involvement in any intensification programs, may affect individual level of inefficiencies. Knowing these factors, we can simply regress these factors as independent variables against the estimated individual level of technical (profit) inefficiency as the dependent variable.

The panel data set used in this study covers wetland and dryland farming, both rice and secondary crops. It would be interesting to assess the inefficiency level of the dryland rice and secondary crop farming practices, using a similar approach used in this study. This approach can also be extended to handle a multiproduct production as well as multiproduct profit function. The multiproduct framework may best represent the real farming activities.

The impact of price support and input subsidy policies on consumer and producer surplus is not analyzed in this study. Future research is needed to assess the welfare impact of the policy alternatives on both producers and consumers, in addition to the government cost.

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APPENDICES

Appendix 2.1. The BIMAS Package per Hectare, 1980

Items	Package A		Package B		Package C	
	Total	Value (Rp)	Total	Value (Rp)	Total	Value (Rp)
Urea (kg)	200	14000	100	7000	250	17500
TSP (kg)	50	3500	35	2450	75	5250
KCL/K20 (kg)	50	3500	50	3500	50	3500
Insecticide (lt)	2	2460	2	2460	2	2460
Rodenticide (gr)	100	400	100	400	100	400
Seed	-	5000	-	-	-	5000
Spraying Cost	-	2000	-	2000	-	2000
Additional Cost	-	10000	-	10000	-	10000
Total		40860		27810		46110

Source: Adopted from Sugianto (1982)

Appendix 2.2. Fertilizer Price Under BIMAS and INMAS Program

Year	Fertilizer Urea (Rp/kg)	Fertilizer TSP Rp/kg)	Rough Rice Floor Price (Rp/kg)	Rice Floor Price (Rp/kg)	Rough Rice -Urea price Ratio
1974	40.00	40.00	41.80	68.50	1.05
1975	60.00	60.00	58.50	97.00	0.98
1976	80.00	80.00	68.50	108.00	0.86
1977	70.00	70.00	71.00	110.00	1.01
1978	70.00	70.00	75.00	119.50	1.07
1979	70.00	70.00	85.00	140.00	1.21
1980	70.00	70.00	105.00	175.00	1.50
1981	70.00	70.00	120.00	195.00	1.71
1982	90.00	90.00	135.00	214.00	1.93
1983	90.00	90.00	145.00	238.00	1.61
1984	90.00	90.00	165.00	270.00	1.83
1985	100.00	100.00	175.00	285.00	1.75

Source: IFPRI/CAER, 1986.

Appendix 2.3. Trends in Imported and Actual Rice Prices in Jakarta (US$ per ton).

Year	Imported Rice: FOB Bangkok (25% broken)	Imported Rice: Cost to Retail Jakarta	Act. Jakarta Price
1970	125.3	148.6	112.4
1971	93.9	115.5	109.3
1972	103.6	127.5	119.0
1973	116.3	175.8	205.2
1974	493.2	558.7	242.2
1975	311.8	380.5	262.7
1976	222.3	263.3	209.6
1977	237.4	287.3	319.6
1978	327.9	382.2	318.8
1979	308.3	362.0	272.5
1980	403.9	466.4	319.0
1981	416.4	470.1	325.0
1982	271.6	320.9	348.0

Source: World Bank 1982 (adopted from Nestel, 1985)
Exchange Rate at Rp 660 = US$ 1

Appendix 2.4. Price Structure For Urea and Triple Superphosphate (TSP) in 1982

Fertilizer Price	US$/Ton	Rp/Kg
Urea:		
FOB Europe	185	
Ex-Factory Price (Palembang)	198	
Handling/distrib. to Retail.	+40	
Transport to Farm	+ 4	
Farm-gate Price	242	160
Financial Farm-gate Price	106	70
TSP:		
FOB Florida	185	
Ocean Freight & Insurance	+60	
Handling/distrib. to Retail.	+35	
Transport to Farm	+ 4	
Farm-gate Price	259	171
Financial Farm-gate Price	106	70

Source: Nestel (1985)
Exchange Rate at Rp 660 = US$ 1

Appendix 2.5. Budget Cost of Fertilizer Subsidy (1981/1982)

	Quantity (000 Ton)	Subsidy	
		Rp.Billion	US$ Million
Domestically Produced:			
Urea	1,758	76,289	115.6
TSP	487	93,445	141.6
Ammonium Sulphate	120	8,594	13.0
Subtotal	2,365	178,328	270.2
Imported:			
Urea	200	27,633	41.9
TSP	150	20,724	31.4
Ammonium Sulphate	100	10,296	15.6
Potassium Chloride	50	6,824	10.3
Subtotal	500	65,477	99.2
Total	2,865	243,805	369.4

Source: Ministry of Finance (Adopted from Nestel, 1985)
Exchange Rate at Rp 660 = US$ 1

Appendix 3.1. Derivation of Response Elasticities of the Multinomial Logit Model.

Probability of each event (choice) is

$$P_1 = \frac{1}{1 + \Sigma_j \exp(X\beta_j)}$$

$$P_i = \frac{\exp(X\beta_i\ )}{1 + \Sigma_j \exp(X\beta_j)}$$

In our case subscript 1 represents an event of farmer growing TV, while i and j = 2, 3, represent HYV and MV, respectively. Let $\exp(X\beta_j) = Z_j$ and $1 + \Sigma_j \exp(X\beta_j) = Y$. Taking a partial derivative of P with respect to k^{th} explanatory variables, we get

$$\partial P_j/\partial X_k = \frac{\beta_{jk}\, Z_j\, Y - (\beta_{jk}\, Z_j + \beta_{ik}\, Z_i)\, Z_j}{Y^2}$$

$$= \frac{\beta_{jk}\, Z_j\, Y - \beta_{jk}\, Z_j\, Z_j - \beta_{ik}\, Z_j\, Z_i}{Y^2}$$

$$= \frac{\beta_{jk}\, Z_j\, Y}{Y^2} - \frac{\beta_{jk}\, Z_j\, Z_j}{Y^2} - \frac{\beta_{ik}\, Z_j\, Z_i}{Y^2}$$

$$= (\beta_{jk}\, P_j - \beta_{jk}\, P_j\, P_j - \beta_{ik}\, P_j\, P_i)$$

Appendix 3.1. (Continued)

$$\partial P_1/\partial X_k = - \frac{\beta_{2k} Z_2}{Y^2} - \frac{\beta_{3k} Z_3}{Y^2}$$

$$= - \beta_{2k} (P_2/P_1) - \beta_{3k} (P_3/P_1)$$

where ∂ is a symbol of partial derivative. The response elasticities (E_{ik}) can be calculated from

$$E_{1k} = (dP_1/dX_k)(X_k/P_1)$$

$$E_{2k} = (dP_2/dX_k)(X_k/P_2)$$

$$E_{3k} = (dP_3/dX_k)(X_k/P_3)$$

evaluated at the mean value of P and X_k.

Appendix 5.1. Input and Output Per Hectare of High Yielding Rice Variety (HYV)

Input and Output	Season (W=wet, D=dry)					
	W75/76	D76	W76/77	D77	W82/83	D83
Land (Ha)	0.6696	0.6213	0.7573	0.5007	0.6431	0.5160
Output (Kg/Ha)	3619.4	2867.7	2370.6	2536.4	4821.9	4235.3
Seed (Kg/Ha)	42.8	45.6	43.5	37.9	46.0	36.8
Urea (kg/Ha)	225.2	181.0	240.2	212.0	257.7	244.4
TSP (kg/Ha)	47.8	57.4	58.1	56.3	120.5	108.2
Labor (hrs/ha)	1538.2	1315.7	1321.2	1221.8	1424.9	1356.0
Hired preharvst	524.7	529.7	607.7	533.8	507.6	474.4
Hired harvest*	767.4	605.5	472.5	486.4	581.3	578.7
Family	246.1	180.5	240.9	201.7	335.9	302.9
Price (Rp/Kg)						
Rough Rice	58.28	59.32	61.30	66.86	111.00	136.56
Seed	81.41	77.16	76.29	104.02	217.16	212.80
Urea	77.31	77.03	70.91	70.65	84.86	88.15
TSP	77.31	77.04	70.67	71.09	86.12	89.23
Wage	45.43	46.25	46.37	51.48	141.21	136.72
Revenue (Rp/Ha)	210940	170112	145318	169584	535231	578372
Var.Cost (Rp/Ha)	94470	86734	85721	85820	243445	224422
Profit (Rp/Ha)	116470	83378	59597	83764	291786	353950
N (Observations)	32	37	43	44	65	74

Appendix 5.2. Input and Output Per Hectare of Traditional Rice Variety (TV)

Input and Output	Season (W=wet, D=dry)					
	W75/76	D76	W76/77	D77	W82/83	D83
Land (Ha)	0.3793	0.3063	0.3508	0.3025	0.3796	0.3265
Output (Kg/Ha)	3220.3	3236.0	2633.9	2255.2	3461.5	3677.0
Seed (Kg/Ha)	35.4	38.6	38.5	39.0	38.9	39.7
Urea (kg/Ha)	195.5	192.2	205.1	195.3	262.7	248.5
TSP (kg/Ha)	76.5	68.1	61.0	57.9	111.4	110.7
Labor (hrs/ha)	1364.6	1409.4	1202.1	1289.0	1377.3	1547.4
Hired preharvst	610.3	610.2	396.1	555.8	597.1	639.4
Hired harvest*	396.6	418.4	292.3	295.3	297.8	336.0
Family	357.7	380.7	413.7	437.9	482.3	572.0
Price (Rp/Kg)						
Rough Rice	63.70	69.21	66.56	77.97	138.87	136.67
Seed	65.05	70.66	74.54	89.46	150.91	155.40
Urea	77.86	77.62	70.80	71.02	89.12	89.13
TSP	78.32	76.88	70.44	71.39	91.00	92.22
Wage	50.60	49.18	58.93	52.20	136.91	130.19
Revenue (Rp/Ha)	205133	223964	175312	175838	480698	502536
Var.Cost (Rp/Ha)	92565	92584	92528	88778	227986	239983
Profit (Rp/Ha)	112568	131099	82784	87060	252712	262553
N (Observations)	131	129	125	119	91	87

Appendix 5.3. Input and Output Per Hectare of Mixed Varieties (MV)

Input and Output	Season (W=wet, D=dry)					
	W75/76	D76	W76/77	D77	W82/83	D83
Land (Ha)	1.9139	0.5365	0.3140	0.4148	0.4050	0.3832
Output (Kg/Ha)	2640.9	3007.9	3371.9	2330.0	4076.4	4104.4
Seed (Kg/Ha)	48.5	45.7	56.1	33.2	36.1	40.2
Urea (kg/Ha)	147.7	163.6	233.6	152.4	254.7	252.1
TSP (kg/Ha)	27.5	47.5	86.8	32.7	161.3	157.1
Labor (hrs/ha)	1347.6	1588.2	1252.3	1283.7	1647.5	1665.7
Hired preharvst	664.2	652.7	385.6	466.1	739.4	553.8
Hired harvest*	509.2	650.7	436.6	488.1	336.0	473.2
Family	174.3	284.9	387.8	329.5	572.0	638.8
Price (Rp/Kg)						
Rough Rice	61.25	63.73	63.50	66.67	126.67	141.08
Seed	78.75	69.25	75.00	105.50	155.40	170.40
Urea	79.00	74.50	70.00	70.78	89.13	91.00
TSP	79.50	76.50	70.00	70.78	90.27	91.00
Wage	47.76	46.69	48.30	51.57	143.06	132.66
Revenue (Rp/Ha)	161755	191695	214116	155341	516358	579046
Var.Cost (Rp/Ha)	82035	93140	87122	82804	278536	265059
Profit (Rp/Ha)	79720	98555	126994	72537	237822	313987
N (Observations)	8	5	3	9	15	10

Appendix 5.4. Abbreviation of the Variables

Variables Used in the Production and Profit Functions:

LKGS: natural logarithm of kilograms of seed used.

LKGN: Natural Log. of kilograms of urea used.

LKGP: Natural Log. of kilograms of TSP used

LLAB: Natural log. of hours of laborers used.

LHA : Natural Log. of hectares of cultivated land.

LKGSKGS = LKGS*LKGS

LKGNKGN = LKGN*LKGN

LKGPKGP = LKGP*LKGP

LLABLAB = LLAB*LLAB

LKGSKGN = LKGS*LKGN

LKGSKGP = LKGS*LKGP

LKGSLAB = LKGS*LLAB

LKGNKGP = LKGN*LKGP

LKGNLAB = LKGN*LLAB

LKGPLAB = LKGP*LLAB

LHALHA = LHA*LHA

LHAKGS = LHA*LKGS

LHAKGN = LHA*LKGN

LHAKGP = LHA*LKGP

LHALAB = LHA*LLAB

LPS: natural Logarithm of per kilogram seed price normalized by price of rice.

LPF: natural logarithm of per kilogram fertilizer price normalized by per kilogram price of rice.

Appendix 5.4. (Continued)

LWG: natural logarithm of per hour labor wage normalized by price of rice.

LPSLPS = LPS*LPS

LPFLPF = LPF*LPF

LWGLWG = LWG*LWG

LPSLPF = LPS*LPF

LPSLWG = LPS*LWG

LPFLWG = LPF*LWG

LHALPS = LHA*LPS

LHALPF = LHA*LPF

LHALWG = LHA*LWG

DP: dummy variable of pesticide use, equals 1 if farmer uses pesticides and equals 0 otherwise.

DV1: dummy HYV variety, equals 1 if HYV, zero otherwise

DV2 : dummy of Mixed Varieties (MV), equals 1 if MV, zero otherwise.

Note: traditional variety (TV) is the control.

DSS: dummy variable of season, equals 1 if wet season, zero otherwise.

DSIZE: dummy variable of farm size, equals 1 if farm size greater than 0.5 ha, zero otherwise.

DR1: dummy village, equals 1 if desa Lanjan kabupaten Indramayu, zero otherwise.

DR2: dummy village, equals 1 if desa Gunung Wangi kabupaten Majalengka, zero otherwise.

DR3: dummy village, equals 1 if desa Malausma kabupaten Majalengka, zero otherwise.

Appendix 5.4. (Continued)

DR4: dummy village, equals 1 if desa Sukaambit kabupaten Sumedang, zero otherwise.

DR5 : dummy village, equals 1 if desa Ciwangi kabupaten Garut, zero otherwise.

Note: Wargabinangun kabupaten Cirebon is the control village.

Variable Used in the Multinomial Logit Model:

P_1: probability of farmer grows traditional rice variety (TV).

P_2: probability of farmer grows high yielding rice variety (HYV).

P_3: probability of farmer grows mixed variety (MV), both TV and HYV.

$Ln(P_2/P_1)$: natural logarithm of (P_2/P_1).

$Ln(P_3/P_1)$: natural logarithm of (P_3/P_1).

$Ln(P_3/P_2)$: natural logarithm of (P_3/P_2).

PTV: price of TV (Rp/Kg).

PHYV: price of HYV (Rp/Kg).

PF: price of fertilizer (Rp/Kg).

WAGE: labor wage (Rp/hour).

HA: hectares of area cultivated with rice.

Appendix 5.5. Individual Level of Technical Inefficiency Estimated from Cobb-Douglas Production Frontier

OBS	ID	HA	TE	TIE
1	501041	0.43900	0.965581	0.0344191
2	608215	0.38067	0.965450	0.0345496
3	606133	0.12167	0.963772	0.0362275
4	608207	0.58933	0.962232	0.0377680
5	101056	0.33600	0.961426	0.0385738
6	302192	0.16617	0.957572	0.0424276
7	302195	0.22933	0.956930	0.0430696
8	401032	0.08633	0.956897	0.0431025
9	301075	0.55167	0.956171	0.0438295
10	504167	0.13800	0.954806	0.0451938
11	204096	2.48833	0.954338	0.0456625
12	606145	0.37650	0.954329	0.0456711
13	101068	0.42033	0.953795	0.0462048
14	302189	0.55500	0.953326	0.0466741
15	607188	0.89317	0.953202	0.0467975
16	101057	0.18983	0.952472	0.0475282
17	401125	0.46883	0.951562	0.0484383
18	609234	0.49300	0.951515	0.0484854
19	101069	0.46300	0.951474	0.0485256
20	607164	0.54067	0.950991	0.0490087
21	606151	0.25483	0.950862	0.0491377
22	605116	0.26167	0.950615	0.0493852
23	401109	0.21867	0.950374	0.0496262
24	401002	0.24533	0.949882	0.0501179
25	607167	0.98983	0.949467	0.0505330
26	302197	0.49700	0.949163	0.0508366
27	302116	0.36100	0.948565	0.0514351
28	401075	0.16633	0.948453	0.0515467
29	401138	0.16767	0.948427	0.0515728
30	301023	0.15300	0.948242	0.0517579
31	205153	1.45233	0.947771	0.0522287
32	302169	0.48900	0.947522	0.0524776
33	201003	0.48800	0.947268	0.0527317
34	201002	0.52567	0.946468	0.0535319
35	302134	0.49450	0.946295	0.0537049
36	502112	0.18800	0.946243	0.0537566
37	204116	1.19033	0.946199	0.0538007
38	501020	0.41933	0.946085	0.0539154
39	607168	1.88700	0.946083	0.0539173
40	402162	0.18817	0.945522	0.0544779
41	607170	0.37100	0.945391	0.0546087
42	401122	0.56200	0.944937	0.0550629
43	203079	0.80850	0.944438	0.0555621
44	401092	0.14817	0.944196	0.0558038
45	302161	0.31400	0.944137	0.0558625
46	402203	0.15350	0.944001	0.0559985
47	101067	0.23567	0.943627	0.0563726
48	101026	0.15583	0.943118	0.0568818
49	302205	0.55350	0.942850	0.0571505
50	607195	0.13183	0.942830	0.0571702
51	101035	0.32117	0.942420	0.0575795
52	207209	0.36933	0.942350	0.0576500
53	302163	0.41767	0.942279	0.0577214
54	202039	2.48600	0.942160	0.0578395
55	504204	0.43583	0.942083	0.0579166

Appendix 5.5 (Continued)

OBS	ID	HA	TE	TIE
56	504161	0.40183	0.941709	0.0582906
57	504162	0.11033	0.941700	0.0583001
58	206169	0.30833	0.941579	0.0584212
59	402171	0.21700	0.941095	0.0589046
60	302194	0.42667	0.941082	0.0589180
61	302146	0.40417	0.941020	0.0589802
62	302137	0.26200	0.940991	0.0590086
63	302151	0.35033	0.940852	0.0591485
64	401095	0.33133	0.940680	0.0593204
65	102119	0.41150	0.940596	0.0594039
66	202066	0.74467	0.940314	0.0596862
67	201001	0.65083	0.940290	0.0597103
68	102157	0.71283	0.940219	0.0597807
69	206158	0.51200	0.940037	0.0599633
70	603052	0.21400	0.940018	0.0599817
71	402201	0.09067	0.939721	0.0602792
72	302144	0.64267	0.939697	0.0603029
73	402167	0.22617	0.939608	0.0603924
74	502080	0.16667	0.939258	0.0607419
75	503135	0.27433	0.939228	0.0607719
76	603070	0.16650	0.939147	0.0608535
77	502062	0.18900	0.938967	0.0610330
78	401069	0.08433	0.938917	0.0610827
79	503143	0.07000	0.938422	0.0615783
80	402155	0.40133	0.938164	0.0618356
81	609241	0.14450	0.937971	0.0620291
82	402150	0.15817	0.937959	0.0620411
83	504168	0.17633	0.937623	0.0623773
84	402168	0.12367	0.936693	0.0633066
85	401041	0.14850	0.936455	0.0635449
86	301070	0.14333	0.936450	0.0635501
87	504201	0.38200	0.936097	0.0639025
88	402179	0.09283	0.936079	0.0639212
89	606147	0.29200	0.935972	0.0640283
90	604074	0.35967	0.935804	0.0641956
91	401077	0.12117	0.935557	0.0644431
92	301038	0.95633	0.935456	0.0645440
93	501045	0.22150	0.935381	0.0646193
94	302209	0.67633	0.935380	0.0646203
95	401124	0.10617	0.934833	0.0651667
96	401034	0.31667	0.934703	0.0652972
97	301004	0.23967	0.934555	0.0654450
98	609227	0.32817	0.934407	0.0655935
99	302142	0.15917	0.934108	0.0658917
100	502057	0.23567	0.933890	0.0661095
101	101073	0.11417	0.933778	0.0662219
102	301067	0.64550	0.933558	0.0664424
103	401043	0.28583	0.933526	0.0664735
104	102113	0.73783	0.932380	0.0676202
105	102111	0.60083	0.932220	0.0677801
106	609242	0.06317	0.932208	0.0677919
107	201009	0.27233	0.931696	0.0683039
108	204124	0.21333	0.931656	0.0683438
109	209250	0.17783	0.931635	0.0683646
110	102220	2.85650	0.931201	0.0687995

Appendix 5.5. (Continued)

OBS	ID	HA	TE	TIE
111	302131	0.36833	0.931190	0.0688103
112	301105	0.18633	0.931188	0.0688125
113	601010	0.38867	0.931021	0.0689787
114	208225	0.90200	0.930998	0.0690022
115	609245	0.37650	0.930912	0.0690878
116	603043	0.15933	0.930761	0.0692394
117	203080	0.25383	0.930562	0.0694383
118	205151	0.60733	0.930370	0.0696304
119	301110	0.15733	0.930123	0.0698772
120	402176	0.18433	0.930064	0.0699363
121	302182	0.31650	0.929702	0.0702982
122	202061	2.08900	0.929681	0.0703193
123	301055	0.46500	0.929674	0.0703256
124	605108	0.07233	0.929179	0.0708210
125	504197	0.17350	0.928175	0.0718248
126	401036	0.08567	0.928097	0.0719032
127	302120	0.06333	0.928068	0.0719324
128	502081	0.20933	0.927409	0.0725915
129	205132	0.58050	0.926778	0.0732221
130	503136	0.16700	0.925246	0.0747541
131	609244	0.18850	0.925022	0.0749777
132	602034	0.11683	0.924062	0.0759377
133	601005	0.05433	0.923591	0.0764089
134	609231	0.17733	0.923468	0.0765317
135	101001	2.52400	0.923444	0.0765557
136	209232	0.10833	0.923203	0.0767972
137	302199	0.92267	0.923195	0.0768055
138	401058	0.15967	0.922682	0.0773178
139	209241	0.68867	0.922072	0.0779277
140	101017	0.72300	0.921714	0.0782861
141	301058	0.21667	0.921315	0.0786854
142	402208	0.39217	0.920935	0.0790652
143	605109	0.35533	0.919889	0.0801111
144	302147	0.08433	0.919719	0.0802808
145	501034	0.15583	0.919540	0.0804599
146	608205	0.65983	0.918774	0.0812264
147	205136	0.11983	0.918177	0.0818229
148	401049	0.52400	0.917970	0.0820298
149	302143	0.61900	0.917885	0.0821155
150	204114	0.24000	0.917564	0.0824361
151	402169	0.16067	0.916763	0.0832369
152	302153	0.92017	0.916563	0.0834368
153	101094	0.46417	0.916240	0.0837602
154	102194	0.35700	0.915884	0.0841157
155	603068	0.50317	0.913612	0.0863877
156	501008	0.46250	0.913259	0.0867411
157	601016	1.10250	0.912696	0.0873039
158	504169	0.17033	0.911583	0.0884173
159	101089	0.29000	0.911079	0.0889215
160	401063	0.17917	0.910556	0.0894440
161	102126	0.76700	0.908945	0.0910548
162	603065	0.71200	0.906839	0.0931606
163	401006	0.39383	0.905463	0.0945367
164	302207	0.55433	0.903213	0.0967868
165	501001	0.37333	0.901846	0.0981537

Appendix 5.5. (Continued)

OBS	ID	HA	TE	TIE
166	301010	0.102333	0.901552	0.098448
167	401037	0.190333	0.899745	0.100255
168	301084	0.611500	0.899374	0.100626
169	603062	0.212000	0.893669	0.106331
170	603067	0.350000	0.891260	0.108740
171	603053	0.343167	0.880566	0.119434

Notes:

OBS: observation

ID: respondent's identification number

HA: average (over time) farm size

TE: technical efficiency

TIE: technical inefficiency

Appendix 5.6. Individual Level of Technical Inefficiency Estimated From Translog Production Frontier

OBS	ID	HA	TE	TIE
1	501041	0.43900	0.965619	0.0343810
2	608215	0.38067	0.965478	0.0345218
3	606133	0.12167	0.963660	0.0363401
4	608207	0.58933	0.961980	0.0380204
5	101056	0.33600	0.961097	0.0389034
6	302192	0.16617	0.956836	0.0431642
7	302195	0.22933	0.956120	0.0438797
8	401032	0.08633	0.956084	0.0439165
9	301075	0.55167	0.955271	0.0447288
10	504167	0.13800	0.953741	0.0462588
11	204096	2.48833	0.953214	0.0467859
12	606145	0.37650	0.953204	0.0467957
13	101068	0.42033	0.952603	0.0473969
14	302189	0.55500	0.952073	0.0479266
15	607188	0.89317	0.951934	0.0480659
16	101057	0.18983	0.951108	0.0488924
17	401125	0.46883	0.950076	0.0499243
18	609234	0.49300	0.950022	0.0499779
19	101069	0.46300	0.949976	0.0500236
20	607164	0.54067	0.949427	0.0505726
21	606151	0.25483	0.949281	0.0507194
22	605116	0.26167	0.948999	0.0510010
23	401109	0.21867	0.948724	0.0512756
24	401002	0.24533	0.948164	0.0518363
25	607167	0.98983	0.947690	0.0523102
26	302197	0.49700	0.947343	0.0526571
27	302116	0.36100	0.946658	0.0533420
28	401075	0.16633	0.946530	0.0534698
29	401138	0.16767	0.946500	0.0534998
30	301023	0.15300	0.946288	0.0537118
31	205153	1.45233	0.945748	0.0542518
32	302169	0.48900	0.945462	0.0545376
33	201003	0.48800	0.945170	0.0548295
34	201002	0.52567	0.944250	0.0557501
35	302134	0.49450	0.944051	0.0559494
36	502112	0.18800	0.943991	0.0560089
37	204116	1.19033	0.943940	0.0560597
38	501020	0.41933	0.943808	0.0561920
39	607168	1.88700	0.943806	0.0561942
40	402162	0.18817	0.943159	0.0568409
41	607170	0.37100	0.943008	0.0569919
42	401122	0.56200	0.942483	0.0575167
43	203079	0.80850	0.941906	0.0580940
44	401092	0.14817	0.941626	0.0583739
45	302161	0.31400	0.941558	0.0584419
46	402203	0.15350	0.941401	0.0585994
47	101067	0.23567	0.940967	0.0590330
48	101026	0.15583	0.940376	0.0596239
49	302205	0.55350	0.940064	0.0599358
50	607195	0.13183	0.940041	0.0599588
51	101035	0.32117	0.939566	0.0604345
52	207209	0.36933	0.939484	0.0605164
53	302163	0.41767	0.939401	0.0605995
54	202039	2.48600	0.939263	0.0607369
55	504204	0.43583	0.939173	0.0608265

Appendix 5.6. (Continued)

OBS	ID	HA	TE	TIE
56	504161	0.40183	0.938738	0.0612620
57	504162	0.11033	0.938727	0.0612730
58	206169	0.30833	0.938586	0.0614141
59	402171	0.21700	0.938022	0.0619775
60	302194	0.42667	0.938007	0.0619931
61	302146	0.40417	0.937934	0.0620657
62	302137	0.26200	0.937901	0.0620987
63	302151	0.35033	0.937738	0.0622619
64	401095	0.33133	0.937537	0.0624626
65	102119	0.41150	0.937440	0.0625600
66	202066	0.74467	0.937110	0.0628896
67	201001	0.65083	0.937082	0.0629178
68	102157	0.71283	0.937000	0.0630000
69	206158	0.51200	0.936787	0.0632134
70	603052	0.21400	0.936765	0.0632349
71	402201	0.09067	0.936417	0.0635826
72	302144	0.64267	0.936390	0.0636104
73	402167	0.22617	0.936285	0.0637151
74	502080	0.16667	0.935876	0.0641240
75	503135	0.27433	0.935841	0.0641592
76	603070	0.16650	0.935745	0.0642546
77	502062	0.18900	0.935535	0.0644649
78	401069	0.08433	0.935477	0.0645230
79	503143	0.07000	0.934896	0.0651038
80	402155	0.40133	0.934594	0.0654055
81	609241	0.14450	0.934367	0.0656325
82	402150	0.15817	0.934353	0.0656465
83	504168	0.17633	0.933959	0.0660412
84	402168	0.12367	0.932867	0.0671332
85	401041	0.14850	0.932586	0.0674135
86	301070	0.14333	0.932580	0.0674197
87	504201	0.38200	0.932166	0.0678344
88	402179	0.09283	0.932144	0.0678564
89	606147	0.29200	0.932017	0.0679825
90	604074	0.35967	0.931821	0.0681795
91	401077	0.12117	0.931529	0.0684711
92	301038	0.95633	0.931410	0.0685900
93	501045	0.22150	0.931321	0.0686788
94	302209	0.67633	0.931320	0.0686800
95	401124	0.10617	0.930676	0.0693242
96	401034	0.31667	0.930522	0.0694783
97	301004	0.23967	0.930347	0.0696527
98	609227	0.32817	0.930172	0.0698279
99	302142	0.15917	0.929820	0.0701801
100	502057	0.23567	0.929563	0.0704374
101	101073	0.11417	0.929430	0.0705703
102	301067	0.64550	0.929169	0.0708309
103	401043	0.28583	0.929132	0.0708677
104	102113	0.73783	0.927776	0.0722244
105	102111	0.60083	0.927586	0.0724138
106	609242	0.06317	0.927572	0.0724278
107	201009	0.27233	0.926966	0.0730344
108	204124	0.21333	0.926918	0.0730817
109	209250	0.17783	0.926894	0.0731064
110	102220	2.85650	0.926378	0.0736221

Appendix 5.6. (Continued)

OBS	ID	HA	TE	TIE
111	302131	0.36833	0.926365	0.073635
112	301105	0.18633	0.926362	0.073638
113	601010	0.38867	0.926165	0.073835
114	208225	0.90200	0.926137	0.073863
115	609245	0.37650	0.926036	0.073964
116	603043	0.15933	0.925856	0.074144
117	203080	0.25383	0.925620	0.074380
118	205151	0.60733	0.925392	0.074608
119	301110	0.15733	0.925099	0.074901
120	402176	0.18433	0.925028	0.074972
121	302182	0.31650	0.924598	0.075402
122	202061	2.08900	0.924573	0.075427
123	301055	0.46500	0.924566	0.075434
124	605108	0.07233	0.923977	0.076023
125	504197	0.17350	0.922782	0.077218
126	401036	0.08567	0.922689	0.077311
127	302120	0.06333	0.922654	0.077346
128	502081	0.20933	0.921869	0.078131
129	205132	0.58050	0.921117	0.078883
130	503136	0.16700	0.919289	0.080711
131	609244	0.18850	0.919022	0.080978
132	602034	0.11683	0.917874	0.082126
133	601005	0.05433	0.917311	0.082689
134	609231	0.17733	0.917164	0.082836
135	101001	2.52400	0.917135	0.082865
136	209232	0.10833	0.916846	0.083154
137	302199	0.92267	0.916836	0.083164
138	401058	0.15967	0.916223	0.083777
139	209241	0.68867	0.915493	0.084507
140	101017	0.72300	0.915063	0.084937
141	301058	0.21667	0.914585	0.085415
142	402208	0.39217	0.914130	0.085870
143	605109	0.35533	0.912875	0.087125
144	302147	0.08433	0.912672	0.087328
145	501034	0.15583	0.912457	0.087543
146	608205	0.65983	0.911537	0.088463
147	205136	0.11983	0.910821	0.089179
148	401049	0.52400	0.910573	0.089427
149	302143	0.61900	0.910470	0.089530
150	204114	0.24000	0.910085	0.089915
151	402169	0.16067	0.909122	0.090878
152	302153	0.92017	0.908882	0.091118
153	101094	0.46417	0.908493	0.091507
154	102194	0.35700	0.908066	0.091934
155	603068	0.50317	0.905334	0.094666
156	501008	0.46250	0.904908	0.095092
157	601016	1.10250	0.904231	0.095769
158	504169	0.17033	0.902891	0.097109
159	101089	0.29000	0.902284	0.097716
160	401063	0.17917	0.901655	0.098345
161	102126	0.76700	0.899715	0.100285
162	603065	0.71200	0.897179	0.102821
163	401006	0.39383	0.895522	0.104478
164	302207	0.55433	0.892812	0.107188
165	501001	0.37333	0.891166	0.108834

Appendix 5.6. (Continued)

OBS	ID	HA	TE	TIE
166	301010	0.102333	0.890812	0.109188
167	401037	0.190333	0.888637	0.111363
168	301084	0.611500	0.888191	0.111809
169	603062	0.212000	0.881334	0.118666
170	603067	0.350000	0.878444	0.121556
171	603053	0.343167	0.865664	0.134336

Notes:

Variable definition as in appendix 5.5.

Appendix 5.7. Individual Level of Profit Inefficiency Estimated from Cobb-Douglas Profit Frontier

OBS	ID	HA	PE	PIE
1	501041	0.43900	0.930522	0.069478
2	608215	0.38067	0.930165	0.069835
3	608207	0.58933	0.925434	0.074566
4	606133	0.12167	0.925035	0.074965
5	101056	0.33600	0.914863	0.085137
6	504167	0.13800	0.909389	0.090611
7	606145	0.37650	0.909346	0.090654
8	605116	0.26167	0.905866	0.094134
9	401109	0.21867	0.905827	0.094173
10	302195	0.22933	0.905262	0.094738
11	607164	0.54067	0.903816	0.096184
12	606151	0.25483	0.903656	0.096344
13	204096	2.48833	0.902685	0.097315
14	401125	0.46883	0.902267	0.097733
15	101068	0.42033	0.901974	0.098026
16	504204	0.43583	0.901798	0.098202
17	504168	0.17633	0.901602	0.098398
18	607170	0.37100	0.900488	0.099512
19	401032	0.08633	0.899904	0.100096
20	301075	0.55167	0.897939	0.102061
21	302189	0.55500	0.896692	0.103308
22	609234	0.49300	0.896558	0.103442
23	302192	0.16617	0.895092	0.104908
24	607188	0.89317	0.894791	0.105209
25	607168	1.88700	0.894440	0.105560
26	401095	0.33133	0.894414	0.105586
27	607167	0.98983	0.893996	0.106004
28	501020	0.41933	0.893730	0.106270
29	401002	0.24533	0.893542	0.106458
30	201002	0.52567	0.892572	0.107428
31	201003	0.48800	0.892442	0.107558
32	201001	0.65083	0.892167	0.107833
33	401075	0.16633	0.892058	0.107942
34	101026	0.15583	0.891980	0.108020
35	302151	0.35033	0.891334	0.108666
36	302197	0.49700	0.890950	0.109050
37	504162	0.11033	0.890909	0.109091
38	302144	0.64267	0.890215	0.109785
39	202066	0.74467	0.889810	0.110190
40	607195	0.13183	0.889323	0.110677
41	102119	0.41150	0.889134	0.110866
42	302169	0.48900	0.888701	0.111299
43	102220	2.85650	0.888352	0.111648
44	302116	0.36100	0.887692	0.112308
45	204116	1.19033	0.887678	0.112322
46	101057	0.18983	0.887677	0.112323
47	503143	0.07000	0.886307	0.113693
48	401043	0.28583	0.886164	0.113836
49	301058	0.21667	0.885950	0.114050
50	402162	0.18817	0.885215	0.114785
51	401122	0.56200	0.884704	0.115296
52	504161	0.40183	0.884692	0.115308
53	101069	0.46300	0.884372	0.115628
54	401069	0.08433	0.884183	0.115817
55	302134	0.49450	0.884023	0.115977

Appendix 5. 7. (Continued)

OBS	ID	HA	PE	PIE
56	302194	0.42667	0.883347	0.116653
57	209232	0.10833	0.882712	0.117288
58	205153	1.45233	0.882663	0.117337
59	606147	0.29200	0.882375	0.117625
60	402179	0.09283	0.881468	0.118532
61	401092	0.14817	0.881172	0.118828
62	203079	0.80850	0.880792	0.119208
63	302163	0.41767	0.880780	0.119220
64	503135	0.27433	0.880706	0.119294
65	402201	0.09067	0.880547	0.119453
66	301038	0.95633	0.880525	0.119475
67	504201	0.38200	0.880005	0.119995
68	302137	0.26200	0.879705	0.120295
69	402203	0.15350	0.879275	0.120725
70	102113	0.73783	0.878830	0.121170
71	208225	0.90200	0.878772	0.121228
72	302146	0.40417	0.878443	0.121557
73	302161	0.31400	0.877798	0.122202
74	207209	0.36933	0.876965	0.123035
75	609242	0.06317	0.876394	0.123606
76	302142	0.15917	0.875209	0.124791
77	401124	0.10617	0.874334	0.125666
78	401138	0.16767	0.874043	0.125957
79	401077	0.12117	0.873322	0.126678
80	302199	0.92267	0.872338	0.127662
81	401034	0.31667	0.872017	0.127983
82	301023	0.15300	0.870838	0.129162
83	202061	2.08900	0.870275	0.129725
84	402167	0.22617	0.870177	0.129823
85	609241	0.14450	0.870094	0.129906
86	101067	0.23567	0.868848	0.131152
87	302209	0.67633	0.868127	0.131873
88	301067	0.64550	0.868034	0.131966
89	502080	0.16667	0.867687	0.132313
90	601010	0.38867	0.867334	0.132666
91	402176	0.18433	0.867250	0.132750
92	402171	0.21700	0.867223	0.132777
93	202039	2.48600	0.866331	0.133669
94	402155	0.40133	0.866015	0.133985
95	206158	0.51200	0.865964	0.134036
96	301004	0.23967	0.865961	0.134039
97	609245	0.37650	0.865659	0.134341
98	604074	0.35967	0.865300	0.134700
99	401041	0.14850	0.865217	0.134783
100	501045	0.22150	0.865141	0.134859
101	205151	0.60733	0.864151	0.135849
102	302205	0.55350	0.863792	0.136208
103	608205	0.65983	0.860377	0.139623
104	204124	0.21333	0.859565	0.140435
105	504197	0.17350	0.858515	0.141485
106	101035	0.32117	0.858109	0.141891
107	102157	0.71283	0.857865	0.142135
108	609231	0.17733	0.857826	0.142174
109	101094	0.46417	0.857787	0.142213
110	101073	0.11417	0.857532	0.142468

Appendix 5.7. (Continued)

OBS	ID	HA	PE	PIE
111	302131	0.36833	0.857507	0.142493
112	402150	0.15817	0.856403	0.143597
113	301070	0.14333	0.856108	0.143892
114	302182	0.31650	0.855870	0.144130
115	209250	0.17783	0.855182	0.144818
116	605109	0.35533	0.855075	0.144925
117	401058	0.15967	0.854247	0.145753
118	502112	0.18800	0.853608	0.146392
119	601005	0.05433	0.851629	0.148371
120	205132	0.58050	0.851247	0.148753
121	609244	0.18850	0.849845	0.150155
122	603052	0.21400	0.849066	0.150934
123	102126	0.76700	0.847935	0.152065
124	503136	0.16700	0.847578	0.152422
125	609227	0.32817	0.847269	0.152731
126	301105	0.18633	0.845104	0.154896
127	203080	0.25383	0.842738	0.157262
128	301110	0.15733	0.842202	0.157798
129	603043	0.15933	0.841087	0.158913
130	101089	0.29000	0.840512	0.159488
131	302143	0.61900	0.840171	0.159829
132	301055	0.46500	0.839616	0.160384
133	401036	0.08567	0.839027	0.160973
134	602034	0.11683	0.832751	0.167249
135	206169	0.30833	0.832463	0.167537
136	502062	0.18900	0.830935	0.169065
137	504169	0.17033	0.830279	0.169721
138	102111	0.60083	0.829947	0.170053
139	603070	0.16650	0.829388	0.170612
140	101017	0.72300	0.829100	0.170900
141	102194	0.35700	0.828266	0.171734
142	502057	0.23567	0.826818	0.173182
143	302147	0.08433	0.826384	0.173616
144	209241	0.68867	0.825109	0.174891
145	501008	0.46250	0.823593	0.176407
146	205136	0.11983	0.822588	0.177412
147	402208	0.39217	0.820492	0.179508
148	302153	0.92017	0.820399	0.179601
149	301084	0.61150	0.820187	0.179813
150	204114	0.24000	0.818403	0.181597
151	401049	0.52400	0.818318	0.181682
152	605108	0.07233	0.817736	0.182264
153	401063	0.17917	0.817155	0.182845
154	201009	0.27233	0.815700	0.184300
155	603053	0.34317	0.814173	0.185827
156	401006	0.39383	0.811903	0.188097
157	502081	0.20933	0.809714	0.190286
158	601016	1.10250	0.807777	0.192223
159	402169	0.16067	0.802963	0.197037
160	401037	0.19033	0.800271	0.199729
161	301010	0.10233	0.797227	0.202773
162	501034	0.15583	0.796413	0.203587
163	302120	0.06333	0.796208	0.203792
164	402168	0.12367	0.795409	0.204591
165	101001	2.52400	0.792792	0.207208

Appendix 5.7. (Continued)

OBS	ID	HA	PE	PIE
166	302207	0.554333	0.788484	0.211516
167	603065	0.712000	0.768216	0.231784
168	501001	0.373333	0.763551	0.236449
169	603068	0.503167	0.746916	0.253084
170	603062	0.212000	0.745791	0.254209
171	603067	0.350000	0.711396	0.288604

Notes:

OBS: observation

ID: respondent's identification number

HA: average (over time) farm size

PE: profit efficiency

PIE: profit inefficiency

Appendix 5.8. Individual Level of Profit Inefficiency Estimated From Translog Profit Frontier

OBS	ID	HA	PE	PIE
1	608215	0.38067	0.930592	0.069408
2	501041	0.43900	0.927429	0.072571
3	606133	0.12167	0.923098	0.076902
4	608207	0.58933	0.920333	0.079667
5	101056	0.33600	0.916599	0.083401
6	504167	0.13800	0.905507	0.094493
7	606145	0.37650	0.905310	0.094690
8	401125	0.46883	0.905135	0.094865
9	607164	0.54067	0.901904	0.098096
10	504168	0.17633	0.901454	0.098546
11	605116	0.26167	0.900878	0.099122
12	401109	0.21867	0.899479	0.100521
13	302195	0.22933	0.899416	0.100584
14	609234	0.49300	0.899252	0.100748
15	504204	0.43583	0.898705	0.101295
16	606151	0.25483	0.896884	0.103116
17	401032	0.08633	0.895992	0.104008
18	101068	0.42033	0.895839	0.104161
19	401002	0.24533	0.895528	0.104472
20	302192	0.16617	0.895411	0.104589
21	607188	0.89317	0.892238	0.107762
22	301075	0.55167	0.891512	0.108488
23	402162	0.18817	0.889718	0.110282
24	607170	0.37100	0.889227	0.110773
25	401095	0.33133	0.889201	0.110799
26	201001	0.65083	0.889179	0.110821
27	302189	0.55500	0.889138	0.110862
28	607167	0.98983	0.889069	0.110931
29	501020	0.41933	0.887485	0.112515
30	401075	0.16633	0.886599	0.113401
31	201002	0.52567	0.886555	0.113445
32	204096	2.48833	0.886388	0.113612
33	204116	1.19033	0.886316	0.113684
34	201003	0.48800	0.886050	0.113950
35	504162	0.11033	0.885754	0.114246
36	401122	0.56200	0.885485	0.114515
37	101069	0.46300	0.885147	0.114853
38	302169	0.48900	0.884407	0.115593
39	302197	0.49700	0.882498	0.117502
40	606147	0.29200	0.882491	0.117509
41	607168	1.88700	0.879745	0.120255
42	101026	0.15583	0.879310	0.120690
43	101057	0.18983	0.879110	0.120890
44	302144	0.64267	0.879067	0.120933
45	302151	0.35033	0.878899	0.121101
46	301058	0.21667	0.878590	0.121410
47	209232	0.10833	0.878581	0.121419
48	302137	0.26200	0.878528	0.121472
49	302134	0.49450	0.878236	0.121764
50	302116	0.36100	0.878175	0.121825
51	302161	0.31400	0.877684	0.122316
52	102119	0.41150	0.877654	0.122346
53	401092	0.14817	0.877293	0.122707
54	302163	0.41767	0.876168	0.123832
55	102220	2.85650	0.876150	0.123850

Appendix 5.8. (Continued)

OBS	ID	HA	PE	PIE
56	503135	0.27433	0.875717	0.124283
57	607195	0.13183	0.872934	0.127066
58	301023	0.15300	0.872700	0.127300
59	205153	1.45233	0.872555	0.127445
60	504161	0.40183	0.872231	0.127769
61	208225	0.90200	0.871745	0.128255
62	302194	0.42667	0.871068	0.128932
63	207209	0.36933	0.870099	0.129901
64	401043	0.28583	0.870076	0.129924
65	205151	0.60733	0.869253	0.130747
66	402203	0.15350	0.869098	0.130902
67	102113	0.73783	0.868632	0.131368
68	302146	0.40417	0.867953	0.132047
69	302142	0.15917	0.867852	0.132148
70	203079	0.80850	0.867473	0.132527
71	202066	0.74467	0.866988	0.133012
72	101067	0.23567	0.866451	0.133549
73	503143	0.07000	0.865759	0.134241
74	401077	0.12117	0.864755	0.135245
75	504201	0.38200	0.863499	0.136501
76	402155	0.40133	0.863221	0.136779
77	101035	0.32117	0.863176	0.136824
78	502080	0.16667	0.863031	0.136969
79	402167	0.22617	0.862756	0.137244
80	401034	0.31667	0.862292	0.137708
81	401041	0.14850	0.861602	0.138398
82	401138	0.16767	0.860860	0.139140
83	302131	0.36833	0.860538	0.139462
84	402179	0.09283	0.860464	0.139536
85	302209	0.67633	0.860180	0.139820
86	402201	0.09067	0.859615	0.140385
87	402171	0.21700	0.858791	0.141209
88	401069	0.08433	0.858650	0.141350
89	202039	2.48600	0.857767	0.142233
90	609231	0.17733	0.857745	0.142255
91	301067	0.64550	0.857551	0.142449
92	609245	0.37650	0.856318	0.143682
93	401124	0.10617	0.855853	0.144147
94	301070	0.14333	0.855852	0.144148
95	501045	0.22150	0.854260	0.145740
96	601010	0.38867	0.854110	0.145890
97	609242	0.06317	0.853929	0.146071
98	604074	0.35967	0.853769	0.146231
99	301038	0.95633	0.853211	0.146789
100	206158	0.51200	0.852751	0.147249
101	402176	0.18433	0.850276	0.149724
102	301105	0.18633	0.850244	0.149756
103	608205	0.65983	0.850206	0.149794
104	204124	0.21333	0.849108	0.150892
105	302205	0.55350	0.848916	0.151084
106	101094	0.46417	0.848809	0.151191
107	502112	0.18800	0.848204	0.151796
108	609241	0.14450	0.847970	0.152030
109	202061	2.08900	0.847751	0.152249
110	605109	0.35533	0.846367	0.153633

Appendix 5.8. (Continued)

OBS	ID	HA	PE	PIE
111	504197	0.17350	0.845914	0.154086
112	402150	0.15817	0.845787	0.154213
113	203080	0.25383	0.845162	0.154838
114	301004	0.23967	0.844815	0.155185
115	609244	0.18850	0.844719	0.155281
116	302182	0.31650	0.844054	0.155946
117	102157	0.71283	0.844000	0.156000
118	301110	0.15733	0.842951	0.157049
119	302199	0.92267	0.841552	0.158448
120	206169	0.30833	0.840690	0.159310
121	503136	0.16700	0.840126	0.159874
122	101089	0.29000	0.839524	0.160476
123	609227	0.32817	0.837451	0.162549
124	209250	0.17783	0.836253	0.163747
125	603052	0.21400	0.836051	0.163949
126	101073	0.11417	0.834973	0.165027
127	205132	0.56050	0.832090	0.167910
128	102126	0.76700	0.830830	0.169170
129	602034	0.11683	0.825856	0.174144
130	601005	0.05433	0.824945	0.175055
131	603043	0.15933	0.824370	0.175630
132	401058	0.15967	0.822232	0.177768
133	302143	0.61900	0.821609	0.178391
134	401036	0.08567	0.820907	0.179093
135	101017	0.72300	0.818028	0.181972
136	504169	0.17033	0.817339	0.182661
137	301055	0.46500	0.816312	0.183688
138	204114	0.24000	0.814310	0.185690
139	603070	0.16650	0.814123	0.185877
140	502062	0.18900	0.814043	0.185957
141	102194	0.35700	0.814021	0.185979
142	502057	0.23567	0.813485	0.186515
143	401049	0.52400	0.813104	0.186896
144	302147	0.06433	0.812661	0.187339
145	401063	0.17917	0.811137	0.188863
146	302153	0.92017	0.804862	0.195138
147	501008	0.46250	0.804205	0.195795
148	605108	0.07233	0.802340	0.197660
149	201309	0.27233	0.802319	0.197681
150	102111	0.60083	0.801816	0.198184
151	402169	0.16067	0.798555	0.201445
152	205136	0.11983	0.798249	0.201751
153	402208	0.39217	0.794265	0.205735
154	209241	0.68367	0.794180	0.205820
155	401006	0.39383	0.793915	0.206085
156	601016	1.10250	0.792045	0.207955
157	502081	0.20933	0.790247	0.209753
158	301010	0.10233	0.790209	0.209791
159	603053	0.34317	0.787270	0.212730
160	301034	0.61150	0.778221	0.221779
161	402168	0.12367	0.778118	0.221882
162	401337	0.19033	0.776636	0.223364
163	501034	0.15583	0.775046	0.224954
164	302207	0.55433	0.768929	0.231071
165	302120	0.06333	0.764088	0.235912

Appendix 5.8. (Continued)

OBS	ID	HA	PE	PIE
166	101001	2.52400	0.749106	0.250894
167	603065	0.71200	0.742298	0.257702
168	501001	0.37333	0.736825	0.263175
169	603062	0.21200	0.725962	0.274038
170	603068	0.50317	0.720022	0.279978
171	603067	0.35000	0.691229	0.308771

Note:

Variable definition as in appendix 5.7.

Appendix 5.9. Evaluation of Rice Price Support and Fertilizer Subsidy

A. Data and Parameters

Total Rice Production in West Java

Total rice production in West Java in 1982 amounted to 7,431,497 tons rough rice (CBS, 1984). This is the total wetland rice production.

Total Labor in The Rice Production in West Java

The total labor absorbed in rice production, in West Java, is approximated by multiplying the per hectar labor use by the total harvested area. The per hectar labor use is approximated by using the figures of table 5.1, that is about 150 mandays/hectare. The total annual harvested area of rice in West Java in 1982 was 1,702,504 hectare (CBS, 1984). Using these figures, the labor absorption in West Java's rice production is approximately 255,375,600 mandays/year.

Total Subsidized Fertilizer for Rice Production

Total subsidized fertilizer (Urea+TSP) for rice production in West Java (1982) amounted to 439,180 tons. This figure is the product of total BIMAS fertilizer in West Java (1982) and the ratio of fertilizer use for rice relative to other crops. The total BIMAS fertilizer in West Java in 1982 amounted to 585,576 tons (Deptan/Deperin/APPI, 1984). Note that BIMAS fertilizer was mainly intended to be used for rice production. It is not uncommon, however, that farmers use some of this fertilizer for other crops. To avoid an overestimation a ratio of 0.75 is used; estimated by taking into account per hectare fertilizer use and total harvested area of rice relative to other crops.

Appendix 5.9 (Continued)

Domestic Rice Procurement in West Java

Excess supply of rice (which is assumed to be purchased by the government) due to the implementation of rice floor price is approximated by the annual domestic rice procurement during the period of 1979-1986 (Tabor, 1988). On the average (over time) the domestic procurement of rough rice in Indonesia amounted to approximately 7.5% of the total rough-rice production. Using this ratio and the total rough-rice production in West Java in 1982, we get the estimate of the West Java's domestic procurement in 1982 at 557,360 tons.

Consulting to appendix (5.10), the domestic procurement increases only when the percentage increase of the rice price more than 10%. This can be interpreted that the excess supply of rice (which has to be purchased by the government) will increase only when the percentage increase in the floor price of rice high enough, which could probably need to be above the general inflation rate. This empirical evidence is used to formulate the proposed evaluation procedure, particularly reflected in equation 4.13 and 4.17 of chapter 4.

Price of Rough Rice

The price of rough rice used in this analysis is Rp 135 per kilogram. This was the floor price of rough rice in 1982.

Price of Fertilizer

The fertilizer price used in the analysis is the 1982's price which was Rp 90 per kilogram.

Appendix 5.9 (Continued)

Own- and Cross-Price Elasticity Parameters

The own-price elasticity of rice supply estimated from Cobb-Douglas and Translog are 0.8257 and 0.6026, respectively. The cross-price elasticity of rice supply with respect to fertilizer price is 0.1932 (Cobb-Douglas) and 0.1832 (translog). The cross-price elasticities of labor demand with respect to the prices of rice and fertilizer estimated from Cobb-Douglas (translog) function are 0.8257 (0.9166) and 0.1932 (0.1256), respectively

B. Calculation

(1) Price Support Policy: 1% Increase in Rough-Rice Price

<u>Elasticity Estimated Based on Cobb-Douglas Function:</u>

Government's additional cost:

$$GPR = 1.35 * 557,360 * 1000 = \text{Rp } 752,436,000$$

Additional quantity of rice produced:

$$AQ_{RP(1)} = 0.008257 * 7,431,497 = 61,362 \text{ tons}$$

Additional employment generated:

$$AQ_{L(1)} = 0.008257 * 225,375,600 = 2,108,636 \text{ mandays}$$

Cost per unit of rice produced:

$$C_{R(1)} = 752,436,000/61,362,000 = \text{Rp } 12.26 \text{ /kg}$$

Cost per unit of employment generated:

$$C_{L(1)} = 752,436,000/2,108,636 = \text{Rp } 356.84 \text{ /manday.}$$

<u>Elasticity Estimated Based on Translog Function:</u>

Government's additional cost:

$$GPR = 1.35 * 557,360 * 1000 = \text{Rp } 752,436,000$$

Appendix 5.9 (Continued)

Additional quantity of rice produced:

$$AQ_{RP(1)} = 0.006026 * 7,431,497 = 44,782 \text{ tons}$$

Additional employment generated:

$$AQ_{L(1)} = 0.009166 * 225,375,600 = 2,340,773 \text{ mandays}$$

Cost per unit of rice produced:

$$C_{R(1)} = 752,436,000/44,782,000 = \text{Rp } 16.80 \text{ /kg}$$

Cost per unit of employment generated:

$$C_{L(1)} = 752,436,000/2,340,773 = \text{Rp } 321.45 \text{ /manday.}$$

(2) **Fertilizer Subsidy Policy: 1% Reduction in Fertilizer Price**

Elasticity Estimates from Cobb-Douglas Function:

Government's additional costs:

$$GPF = 0.90 * 439,180 * 1000 = \text{Rp } 395,262,000$$

Additional quantity of rice produced:

$$AQ_{RP(2)} = 0.001932 * 7,431,497 = 14,358 \text{ tons}$$

Additional employment generated:

$$AQ_{l(2)} = 0.001932 * 255,375,600 = 493,385 \text{ mandays}$$

Cost per unit of rough rice produced:

$$C_{R(2)} = 395,262,000/14,358,000 = \text{Rp } 27.5 \text{ /kg}$$

Cost per unit of employment generated:

$$C_{L(2)} = 395,262,000/493,385 = \text{Rp } 801.12 \text{ /manday}$$

Elasticity Estimates from Translog Function:

Government's additional costs:

$$GPF = 0.90 * 439,180 * 1000 = \text{Rp } 395,262,000$$

Appendix 5.9 (Continued)

Additional quantity of rice produced:

$$AQ_{RP(2)} = 0.001832 * 7,431,497 = 13,615 \text{ tons}$$

Additional employment generated:

$$AQ_{l(2)} = 0.001256 * 255,375,600 = 320,752 \text{ mandays}$$

Cost per unit of rough rice produced:

$$C_{R(2)} = 395,262,000/13,615,000 = \text{Rp } 29.03 \text{ /kg}$$

Cost per unit of employment generated:

$$C_{L(2)} = 395,262,000/320,752 = \text{Rp } 1232.30 \text{ /manday}$$

Appendix 5.10. Domestic Rice Procurement (Tons) in Indonesia.

Year	Total Rough Rice Product. (1)	Domestic Procur. (2)	Ratio (3=1/2)	% floor Price Change (4)	Change in Dom. Proc. (5)
1979	24,669,444	331,066	1.34	-	-
1980	27,626,886	2,439,206	8.83	24.0	2,108,140
1981	30,640,867	3,098,871	10.11	14.0	659,665
1982	31,683,652	3,145,635	9.93	12.5	46,764
1983	33,148,256	1,489,808	4.49	7.4	-1,655,827
1984	35,725,992	3,853,488	10.79	14.0	2,093,680
1985	36,870,300	3,123,817	8.79	6.0	-729,671
1986	36,378,453	2,363,033	6.32	0.0	-760,784

(1) and (2) adopted from Tabor (1988): rough rice equivalent
(4) computed from appendix 2.1, using: $(P_1 - P_0)/P_0 * 100\%$ (anually)
(5) computed anually from (2)