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SURVEY OF PHILIPPINE RESEARCH ON THE ECONOMICS OF AGRICULTURE

Part I. Resource Use, Technology Adoption, and Subsidization Alternatives

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The first of a three-part survey on the economics of Philippine agriculture, this paper focuses on empirical studies regarding the determinants of fertilizer use, and the role of input and output subsidies in agricultural development. Based on a simple conceptual framework for the analysis of resource use efficiency in agriculture, it interprets the results of empirical studies on fertilizer use in the Philippines. It also assesses the justifications typically advanced for input subsidies. Finally, lessons for policy and future research as gleaned from the survey of materials are pointed out.

1. Introduction

The last two decades have witnessed a respectable growth of Philippine studies on the economics of agriculture. From its traditional focus on farm management and marketing in the 1960s, the field has expanded to include analyses of agricultural households, rural institutions, sectoral linkages, and relations between the rural economy and the polity. The questions asked have gone beyond characterizing the "nature, conduct, and performance" of agricultural markets, to include as well an explanation of why these markets have evolved the way they did. Where markets do not exist or are highly imperfect, the literature has begun to ask the efficiency implications of alternative institutions (e.g., the interlinking of credit and land). Similarly, the policy questions asked have moved beyond

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the nature and consequences of public policies to explore as well the causes of these policies. Much of these developments have been influenced largely by similar "breakthroughs" in other branches of economics, particularly on the economics of information and industrial organization (Stiglitz, 1988).

Several lessons for policy and research can be learned from these studies. This three-part survey is an attempt to bring these lessons to the fore. Part I, the subject of this paper, focuses on microeconomic analyses of resource use, technology adoption, and subsidization alternatives in Philippine agriculture. Part II will review the state of economic research on agricultural household modelling and rural institutions. Part III will examine studies on sectoral linkages, agricultural transformation, and development policy in the Philippines.

Specifically, the present paper critically examines empirical studies on the determinants of fertilizer use and on the role of input (and output) subsidies in agricultural development. This emphasis on the fertilizer-use literature is not surprising: fertilizer adoption (i.e., its spread and level of use) in the Philippines has become almost synonymous with the adoption of the modern-variety-fertilizer-irrigation technology (hereafter referred to as MV technology). Moreover, by focusing on this literature, the task of critically evaluating empirical results from various studies becomes more tractable.

A note on the coverage of this survey is in order. While there is quite a sizeable amount of writing on the topics covered by the survey, both in the Philippines and abroad, only studies that introduce new information or present new or different analysis and that use an analytical approach, are included. Also, in Part I, although the focus is primarily on studies of Philippine agriculture, an attempt is made to include a fairly general survey of the literature on agricultural technology adoption and subsidization alternatives.

The present paper is organized as follows. Section 2 sets out a simple conceptual framework for the analysis of resource use efficiency in agriculture, which has become the dominant focus of empirical research on Philippine agriculture, at least in the 1970s and early 1980s. The framework is then used in Section 3 to interpret results from empirical studies of fertilizer use in the Philippines. Section 4 critically reviews the justifications which are often typically advanced for input (particularly fertilizer) subsidies. Finally, Section 5 provides some lessons for policy and future research.

2. Resource Use Efficiency: Concepts and Measurements

The efficiency of peasant agriculture has remained a a major object of inquiry in the economics of agriculture. In the 1950s and largely throughout the 1960s, much of the development literature postulated that peasant farmers are poor, strongly risk-averse, and inefficient in their use of resources. This view slowly gave way to Schultz's (1964) "poor but efficient" hypothesis in the 1970s and 1980s. This hypothesis postulates that peasant farmers are poor, not because they utilize their resources inefficiently, but because of restrictions in their resource endowments (both in kinds and quantities).

Following Farrel (1957), economic inefficiency in the use of resources in agriculture can be decomposed into two components. The first one has to do with the farmer's failure to produce the greatest possible output for given combinations of inputs, i.e., technical inefficiency. The other, called allocative (price) inefficiency, results from the farmer's failure to maximize profits from the use of inputs, given the production technology and the economic environment. Figure 1 illustrates this point.

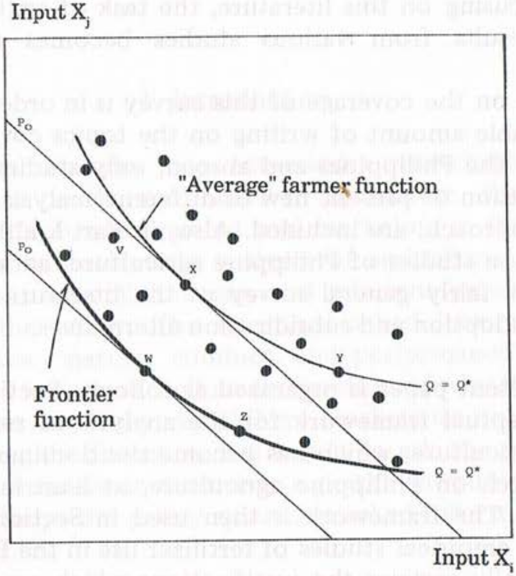

Figure 1- Technical and Allocative Efficiency

The envelope curve labelled "frontier function," often referred to as "maximum technologically possible output" function, represents the correctly defined concept of production function (Varian, 1984). This function can be thought of as that which prevails under controlled environments, i.e., in researchers' experiments in farmers' fields (Roumasset, 1976), or as simply an envelope curve of the most technically efficient farms (Farrel, 1957).

Owing to technical or institutional constraints, a farmer's actual combinations of inputs that yield the output Q^* may lie above the isoquant surface (Q^*) of the frontier function. The "average" farmer function in Figure 1 is one such possibility. Empirically, one can think of this function as that obtained from the fitting of cross-section data using ordinary least squares (OLS) or generalized least squares (GLS) techniques, the usual way production functions are estimated. Assuming the economic environment faced by the farmer is such that the (non-stochastic) input price ratio is given by P_0, input combination X in the figure is allocatively or price efficient but not technically efficient. Y is neither allocatively nor technically efficient. V, on the other hand, may or may not be allocatively efficient,depending on whether the slope of the (technically inefficient) isoquant at that point equates with the slope of the isocost line P_0. Only point W meets the condition for both allocative and price efficiency.

Differences in technical efficiency among farmers may be due to a combination of factors, including biological factors (e.g., soil characteristics, pest incidence, moisture stress), tenure and formal education of farmers, and management of variable inputs (e.g., the timing and methods of input applications). On the other hand, farm-to-farm variability in allocative efficiencies may result from, say, differences in farmers' objective functions. The farmer's goal may not be to maximize profit from the application of, say, fertilizer, but may instead be to minimize the chance that his income falls below a critical (subsistence) level. In this case, even if high fertilizer use will yield a higher expected profit than that by low fertilizer use, the farmer may choose the low-input level if the variability of profit is lower compared with that of the high-input level.

How important have technical and allocative inefficiencies been in Philippine agriculture? Much of the empirical evidence has so far been limited to rice, for three somewhat obvious reasons: (a) systematically collected farm-level data on rice production are widely available; (b) rice is the single most important user of inorganic fertilizer, a major source of production growth in rice, since the early 1970s; and (c) rice is the prime staple in the Philippines.

The earliest systematic analysis of the relative contribution of technical and allocative inefficiencies in Philippine agriculture was that by Herdt and Mandac (1981).[1] They showed that technical inefficiency in rice production contributed about two-thirds of the total yield gap (defined as the difference between the maximum possible yield and the actual yield) during the wet season and about one-half during the dry season (Table 1). Allocative inefficiency, on the other hand, accounted for about 20 and 40 percent during the wet and dry season, respectively. When high interest rates are added to fertilizer costs, the proportion of the yield gap attributed to allocative inefficiency could fall dramatically (Flinn and Smith, 1983).

Defining the yield gap in a slightly different way (i.e., the difference between the potential yield obtainable using the recommended rate of fertilizer application and actual farmers' yield, where the potential yield is not necessarily the maximum yield), Mandac *et al.* (1984) estimated that about 70 percent of the gap could be explained by differences in production environments, with fertilizer application rate explaining 16 percent.

Table 1 — Factors Contributing to Fertilizer Yield Gap, Nueva Ecija, 1974-77

Season	Yield gap* (t/ha)	Percent contribution to gap			
		Technical inefficiency	Allocative inefficiency	Residual	Total
Wet	0.9	67	22	11	100
Dry	1.6	56	38	6	100

*Yield gap is defined as the difference between maximum yield and actual (farmers') yield.

Source: Herdt and Mandac (1981).

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[1] This was part of a larger study on the farm-level constraints to high rice yields in Asia by the International Rice Research Institute (IRRI, 1979).

What the studies of Herdt and Mandac, Mandac *et al.*, and still others (e.g., Kalirajan and Flinn, 1981) who used essentially the same methodology, suggest is that technical and managerial factors represent an important set of options to increase farmers' yields. One implication of this is that efforts aimed at raising farm incomes must pay attention to technological development and investments in human capital. That is, farmers are poor, not because they are allocatively inefficient, but largely because their resources and the technical and economic options available to them are restricted.

3. Agricultural Technology Adoption: Determinants of Fertilizer Use

As noted above, much of the literature on technology adoption in Philippine agriculture has been limited to the modern-rice-variety-fertilizer-irrigation technology (MV technology). In fact, fertilizer adoption has become synonymous with the adoption of MV technology. This is not surprising considering that there exists a high degree of complementarity among fertilizer, modern rice variety, and irrigation (Wickham, Barker, and Rosegrant, 1978; Hayami and Ruttan, 1985). Also, the emphasis of research on rice is partly motivated by the importance of the commodity, as staple, among the majority of Filipinos. The availability of reasonably good cross section and time-series data on rice farms (largely from IRRI) is another factor.

Two approaches have been employed in empirical measurement of the determinants of fertilizer use. The first one involves estimating fertilizer response functions and deriving *indirectly* the factors affecting the level of fertilizer use. One major problem with this is that the right-hand variables of these functions are often not statistically independent from (some component of) their respective error terms, thereby resulting in biased estimates of the parameters.

An alternative approach is to estimate the determinants of fertilizer demand *directly*. This involves specifying a fertilizer demand function which can be estimated singly or jointly with the output supply and other input demand functions. The chosen variables, normally dictated by economic theory, typically include the real price of fertilizer (often defined as the price of fertilizer relative to the price of output), price shifters including the prices of complementary inputs and substitutes, and other (exogenous) variables intended to capture the effects of changing input-output relationships and production constraints (e.g., credit and farm size).

What follows is an assessment of the significance or importance of the major variables that have heretofore dominated the empirical research on fertilizer adoption and the level of fertilizer use.

Farmers' Responsiveness to Price Changes

While economic theory normally dictates what determinants need to be included in an empirical specification of fertilizer demand, the same is of little help with respect to deciding what specific functional form to use. Without *a priori* information about the underlying functional relationship between variables, a multitude of functional forms can indeed be alternatively specified. In practice, and not until lately, a major consideration has been on the cost of estimation. Another is data availability.

The choice of estimating the functional form is important in determining the price elasticity of demand for fertilizer. In linear regression equations specified in natural numbers, the derived price elasticity estimate varies depending on the choice of points on the demand curve. The traditional practice is to compute the elasticity at the mean values of the variables. On the other hand, in a well-specified simultaneous equation system involving the Cobb-Douglas profit function approach, the input demand elasticities must necessarily be constant and are always price elastic.[2]

Another issue concerning the evaluation of the empirical literature on price elasticity of fertilizer demand is the interpretation of the elasticities derived from cross-section and time-series data. In time-series regressions, (usually) annual data for a given period are used to establish causal relationship between fertilizer consumption and a set of hypothesized explanatory variables, including the price of fertilizer. Where the observations correspond to different economic and environmental differences, and without these factors

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[2] Chand and Kaul (1986) draw out other implicit restrictions on the Cobb-Douglas profit function, namely: (1) all variable inputs are complementary, (2) the effect of an increase in a fixed input is symmetric on all variable inputs, (3) symmetry of cross-price elasticities, and (4) the elasticity of input demand with respect to output price is greater than one. For an exposition of the use and misuse of profit functions in agricultural economic research, see Junankar (1989).

specified also in the fertilizer demand equation, the estimates of elasticities obtained from these regressions can best be interpreted as long-run. Data availability often precludes the inclusion of these variables in time-series analysis, especially one where a very limited number of observations (as is often the case in fertilizer demand estimation involving time-series data) are used in the analysis.

On the other hand, in regressions involving cross-section data where the sample farmers have different factor endowments or production constraints, or where there are differences in their rate of adoption of technological innovations (e.g., improved seeds), or where the sample farms have important environmental differences (e.g., climate and soil fertility), short-run price elasticities of fertilizer demand will tend to be overestimated unless these factors are also included in the estimating equation (David, 1976). In effect, what is estimated is a long-run elasticity, reflecting an adjustment along a long-run production function.

These considerations underlie the characterization of the various econometric studies, mostly concentrated in rice farms, on fertilizer demand in the Philippines (Table 2). In most instances, many of the elasticity estimates reported in these studies do not fall neatly as either short-run or long-run elasticities. Other relevant factors that affect fertilizer consumption (e.g., supply constraints) are omitted primarily due to data limitations. However, as briefly noted below, these estimates seem to fall closer to being short-run elasticities.

Elasticity estimates from single-equation models of fertilizer demand tend to consistently yield a value close to negative (—) 0.5. These results contrast markedly with those obtained from more complex models where input demand and output supply are determined jointly as a subset of a system of equations describing the production process. In those models (all making use of the profit-function approach), estimates range from —0.4 to —1.3, depending on the specific functional form of the underlying equations and, of course, on the data analyzed.

As noted earlier, a Cobb-Douglas formulation of profit function always yields price-elastic demand for the variable inputs. Moreover, in this formulation, all inputs are assumed substitutes (certainly hard to justify in cases where, in practice, fertilizer is a complement of, say, irrigation) and the cross-price elasticity of each input with respect to the price of other inputs is constant.

Table 2 — Estimates of the Price Elasticity of Fertilizer Demand

Source	Commodity covered	Period covered	Estimates		Methodology	Data
			Short-run	Long-run		
1. Cordova and David (1985)	Rice	1966-81	–0.5		Single equation, double-log	Pooled cross-section and time series data of Laguna farmers (typically progressive farmers)
2. Monge (1986)	Rice, irrigated	1983	–1.3		Simultaneous equation system (Cobb-Douglas profit function approach)	Cross-section of rice and corn farmers selected nationwide
	Rice, lowland/ non-irrigated	1983	–1.2			
	Rice, upland	1983	–1.3			
	Corn, hybrid	1983	–1.2			
	Corn, traditional	1983	–1.2			
3. David and Barker (1978)	Rice	1966-71	–0.5		Single equation, double-log	Pooled cross-section and time series data of 150 farmers
4. Te and Herdt (1981)	Rice	1979	–0.4		Single equation, double-log	Data for 140 farmers in an IRRI wet season survey in Central Luzon
5. Rodriguez (1975)	All crops	1958-72	–0.6		Single equation, linear	Time series
6. Evenson (1986)	Index of aggregate output per farm	1948-84	–0.4		Simultaneous equation system (Quadratic profit function approach)	Time series — cross-section of regional data

7. Bantilan (1987)	Rice	1970-84	—0.4	Simultaneous equation system (translog profit function approach)	Sample size is 85, Laguna (IRRI loop) farmers
	Rice	1970-84	—0.7		Sample size is 344, Laguna (IRRI loop) farmers
	Rice	1978-84	—0.7	”	Sample size is 139, Laguna (IRRI loop) farmers
	Rice	1970	—0.6		Sample size is 42, Central Luzon (IRRI loop) farmers
	Rice	1982	—0.7	”	Sample size is 109, Central Luzon (IRRI loop) farmers
	Rice	1966-84	—1.1	”	Sample size is 374, Central Luzon (IRRI loop) farmers
	Rice	1979-84	—1.2	”	Sample size is 243, Central Luzon (IRRI loop) farmers
8. Kalirajan and Flinn (1983)	Rice	1978	—1.3	Simultaneous equation system (translog profit function approach)	Sample of 73 Laguna (typically progressive) farmers
9. Kalirajan et al. (1983)	Rice	1978	—1.2	Simultaneous equation system (Cobb-Douglas profit function approach)	Sample of 81 Laguna rice farmers

In any case, where large price changes are involved, the use of constant price elasticity (such as the one derived from a Cobb-Douglas specification) is likely inappropriate. One may suspect that such changes alter the degree of responsiveness of the input demand.

Other formulations of the profit function (e.g., translog) relax these restrictions. Price elasticities of fertilizer demand obtained from these formulations can be elastic, unitary, or inelastic. These are borne out by the results obtained by Bantilan (1987) who made use of a translog profit function and by Evenson (1987) who employed a normalized quadratic profit function.

All of the above studies can be called "micro-oriented" and have ignored the possibility that the prices of crops (outputs) are not entirely exogenous. A consequence of this approach is that the short-run price elasticity is, in absolute terms, necessarily less than the long-run price elasticity. This is due to the lag in farmers' adjustment to new (exogenously determined) prices. In contrast, in what can be called "macro-models" of fertilizer demand, the value of the long-run price elasticity can be less in absolute size than the short-run price elasticity, especially so in a closed economy (Timmer, 1974). In this setting, a decrease in the price of fertilizer would induce an increase in fertilizer application, which would then lead to a decline in output price resulting from the increase in domestic supply relative to domestic demand. The decline in the price of the commodity would raise the price of fertilizer relative to the price of output, which would then decrease the demand for fertilizer.

Limited conclusions can be drawn from the studies reviewed above. But in a recent study for the World Bank, Allen (1986), who surveyed 58 studies of fertilizer demand for a number of Asian countries with monsoon-dependent agricultures (including 11 for the Philippines covering various periods prior to 1980), suggested the following as reasonable and mutually consistent: (i) the price elasticity of demand in a one-year period is likely to lie in the range of −0.4 and −0.6; (ii) for large fertilizer/crop price increases, say 20 to 30 percent, the one-year elasticity would be around −0.8, rising to −1.2 over a three-year period. Similarly, Pinstrup-Andersen (1982) noted that for a number of developing countries, the price elasticity of demand is in the order of −0.5 to −1.0 in the short run, and −1.0 to −2.0 in the long run.

Given these elasticity values, it is fair to say that the significantly high domestic prices of fertilizer vis-a-vis the world prices (with both prices compared at the same point in the marketing chain) in the 1970s and early 1980s have contributed to the relatively low level of fertilizer consumption in the Philippines. This has been aggravated by the policy-induced depression of the prices of agricultural crops (David *et al.,* 1986). Indeed, in the 1980s, the price of nitrogenous fertilizer relative to that of palay in the Philippines has generally been high vis-a-vis those prevailing in neighboring Asian countries (Balisacan, 1989).

Viewed in historical context, the high relative prices of fertilizer in the Philippines and in South and Southeast Asian countries have actually been lower than those in Japan during its early stage of agricultural modernization (Table 3). In fact, the fertilizer-rice price ratios in South and Southeast Asian countries in 1963-65, the years immediately preceding the so-called Green Revolution, were much more favorable than those that prevailed in Japan during its early phase of agricultural development (beginning the last quarter of the nineteenth century). However, whereas the decline in these ratios was accompanied by dramatic increases in rice yields in Japan, gains in rice yield per hectare in South and Southeast Asian countries between 1955-57 and 1963-65 were small. This can be explained by the low priorities accorded by the South and Southeast Asian countries to investments in complementary inputs, human capital development, and research (Hayami and Ruttan, 1985).

Risk and Risk Aversion

One recurrent argument in the development literature over the last two decades has been that risk and risk aversion have been an impediment to the realization of the full potential of modern agricultural technologies, particularly the fertilizer-responsive modern rice technology. The year-to-year variability in input response resulting from stochastic disturbances such as weather and pests and diseases, the argument goes, makes farmers unwilling to purchase profit-maximizing levels of cash inputs because of the risk of losing their investment.

This argument assumes that there is a conflict between profit maximization and risk aversion. That is, high input levels yield, on the average, higher profit, but this also results in greater variability of profits. Risk-averse farmers are therefore willing to accept a lower

Table 3 — Fertilizer-Rice Price Ratio and Rice Yield per Hectare in Selected Asian Countries (1955-57, 1963-65, and 1975-77) and in Japan (1983-1962)

Country	Currency unit	Price of fertilizer per m. ton of nitrogen (1)	Price of rice per m. ton of milled rice[a] (2)	Fertilizer-rice price ratio (1)/(2)	Rice yield per ha, m. ton of paddy[b] (3)
Intercountry comparison					
1955-57					
India	rupee	1,675	417[c]	4.0	1.3
Philippines	peso	962	352	2.7	1.1
Thailand	U.S.$	393	79	5.0	1.4
Japan	1,000 yen	119	77	1.5	4.8
1963-65					
India	rupee	1,750	595	2.9	1.5
Philippines	peso	1,048	530	2.0	1.3
Thailand	U.S.$	229	70	3.3	1.6
Japan	1,000 yen	97	99	1.0	5.0
1975-77					
India	rupee	4,541	1,606	2.8	1.9
Philippines	peso	3,877	1,687	2.3	1.8
Thailand	U.S.$	530	180	2.9	1.8
Japan	1,000 yen	134	343	0.4	6.0
Japan's time series					
1983-87	yen	450	42	10.7	2.6
1993-97	yen	670	69	9.7	2.6
1903-07	yen	815	106	7.7	3.1
1913-17	yen	803	125	6.4	3.5
1923-27	yen	1,021	277	3.7	3.6
1933-37	yen	566	208	2.7	3.8
1953-57	1,000 yen	113	75	1.5	4.3
1963-67	1,000 yen	100	85	1.2	5.1
1973-77	1,000 yen	125	305	0.4	5.8

[a] Wholesale price at a milled rice basis. Data for Japan are converted from a brown ric basis to a milled rice basis assuming 10 percent for processing cost.

[b] Data for Japan are converted from a brown rice basis to a paddy basis assuming 0.8 f a conversion factor.

[c] Price at Sambalpur, Orissa.

Source: Hayami and Ruttan (1985).

mean profit in exchange for the lower variability of profit.

This argument is illustrated in Figure 2, which depicts the probability distribution of profit at low (π_l) and high (π_h) input levels.[3] In panel *a*, the mean and variance of profit for the low input level are lower than those for the high input level. If farmers are risk-neutral, i.e., they maximize expected profits, they would use the high input level because mean profit is higher for π_h than for π_l. But if farmers are risk-averse, they would be using the low input level, for they are more anxious to avoid low incomes than to attain high profit levels. From the viewpoint of society, the decrease in yield resulting from the suboptimal input levels would represent a social cost.

As noted by Roumasset (1976) and Smith and Umali (1983), the critical point in this argument is how profit variability changes as input level increases. If the variability of profits does not change with respect to the level of inputs (panel *b*), even a risk-averse farmer would use the high input level production technique because the mean profit would be higher for π_h. In this case, there is no conflict between risk aversion and profit maximization.

An intermediate case is that shown by panel *c*, where the variance of profit is higher for the high input level than for the low input level. However, the increase in the variance is less compared with the increase in the mean profits. In this case, risk may not significantly affect the optimal level of input use, at least among not so strongly risk-averse farmers.

Experimental studies aimed at measuring the degree of risk aversion among low income farmers have been conducted in a number of developing countries (see, e.g., Roumasset (1976) in the Philippines, Binswanger (1980) in India, Grisley and Kellog in Thailand (1987), and Dillon and Scandizzo (1978) in Brazil). Despite differences in research methodology employed, the studies "suggest that the pure risk preferences of peasant farmers exhibit a surprising degree of cross-cultural homogeneity" (Shalit and Binswanger, 1985, p. 10). That is, once pay-offs exceed some trivial amounts, farmers'

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[3] The probability distribution associated with low input level can be thought of as that for traditional rice varieties, and the high input level for fertilizer-responsive modern rice varieties.

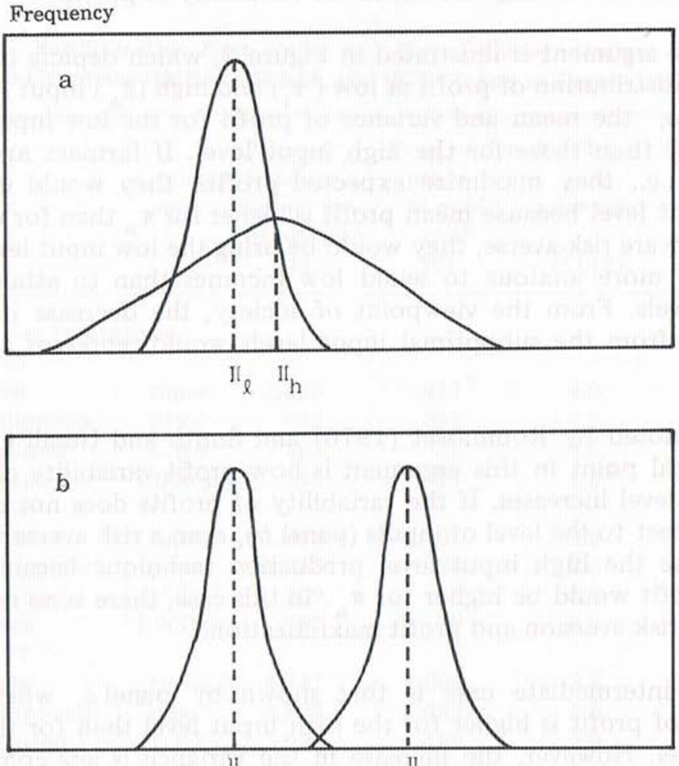

Figure 2. Probability Distribution of Profits at Different N Rates

Source: Smith and Umali (1985, p. 3).

behavior tends to exhibit moderate to intermediate risk aversion, implying small differences in pure risk aversion among farmers.

Increases in profit variability resulting from higher rates of fertilizer application have also been found to be relatively small (Roumasset, 1976; Smith *et al.*, 1983; Smith and Umali, 1985; Rosegrant and Roumasset 1985), at least in irrigated or rainfed rice areas which were generally favorable production environments. That is, the factors responsible for high risk (i.e., adverse weather, pests and diseases) affect yield at low levels of fertilizer use in essentially the same manner as that at high doses. Together with the results that differences in pure risk aversion among farmers tend to be small, these findings suggest that, contrary to popular belief, risk and risk aversion can account for only a small proportion of the fertilizer (and yield) gap. Indeed, with the exception of the Rosegrant and Herdt study, these studies show that the gap between optimal doses under risk neutrality and risk aversion is only between 0.5 and 16.7 percent (Table 4). As noted by Shalit and Binswanger (1985), the Rosegrant-Herdt result is put in question by later findings by Rosegrant and Roumasset (1985) who used the same data but for more years. Rosegrant and Roumasset showed that risk aversion can account for a 6.7 percent to 16.7 percent reduction in fertilizer use (relative to the risk-neutral solution). As discussed in the ensuing section, these findings have important implications for public policy aimed at promoting fertilizer use through fertilizer subsidies.

The results of the above studies should not be generalized to mean that they hold true regardless of production environments. These results, at least by those studies conducted in the Philippines, were obtained from either irrigated areas or rainfed conditions in experimental stations, which are essentially favorable environments. Different results may be obtained from unfavorable environments, such as the flood-prone areas in the Bicol region or the drought-prone areas of the Ilocos region. In these areas, production conditions may be riskier. In rainfed farms, the occurrence of moisture stress is more frequent and its yield-reducing effect may increase with the rate of nitrogen fertilizer. This increase in risk can likely impede optimal input use, the extent of which remains the object of future research.

Agricultural Credit

Another often cited factor constraining technology adoption is

Table 4–Differences between Risk Neutral, Risk Averse and Actual Levels of Fertilizer Use

Study (1)	Crop (2)	Country (3)	Data Source (4)	Optimum dose at risk neutrality (5)	Difference between profit (risk neutral) & utility maximizing (risk averse) level of fertilizer application <15% (6)	Difference between utility maximizing level and farmers' actual level (much larger than 15%) (7)
Ryan and Perrin, 1973[1]	Potatoes	Peru Sierra	Farmer's field trials	N260 kg P260 kg K130 kg		
Roumasset, 1976[2]	Rice	Philippines Laguna province	Experiment station + farmer interviews	Municipality 1: 67 kg N Municipality 2: 44 kg N Municipality 3: 19 kg N	–0.5 –13.0 –7.4	–12.6 –57.5 –100.0
Rosegrant and Herdt, 1981[3]	Rice	Philippines, Central Luzon	Farmer's field trials, 2 years	Irrigated 54 kg N Rainfed 37 kg N	–20.9 –31.0	positive positive
Rosegrant and Roumasset, 1984[4]	Rice	Philippines, Central Luzon	Farmer's field trials, 4 years	Dry season, good irrigation 148 kg N Dry season, average irrigation 112 kg N Wet season, average irrigation 60 kg N Wet season, rainfed 36 kg N	–9.7 –15.4 –6.7 –16.7	negligible[5]
Smith, Umali, Rosegrant and Mandac, 1983[6]	Rainfed Rice	Philippines Bicol	Farmer's field trials,	First season 45 kg N Second season 43 kg N	–9.0 –7.0	–88.0 –87.0
Rangaswamy, 1984	Cotton	South India Tamil Nadu	Experiment station trials, 6 years	60 kg N	–16.0	–86.0

[1] Calculated from Table 6, using Binswanger's severe level of risk aversion.

[2] Calculated from Tables 6.8, 6.9, 6.10, using LSF 3 as the decision rule. Municipality 1 has year round gravity irrigation. Farms in municipality 2 irrigate via low lift pumps. Farms in municipality 3 have unreliable gravity irrigation and inferior soil.

[3] Calculated from Table 4, using moderate levels of risk aversion, and an ample credit constraint of 600 pesos.

[4] Table 3, moderate risk aversion as measured by Sillers.

[5] Author's personal communication.

[6] From Table 3 actual level of use computed from information on pages 4 and 5 in text.

cash constraint or the availability of credit (Rosegrant and Herdt, 1981; Feder *et al.,* 1985; Smith *et al.,* 1983; Mandac and Flinn 1985). It is argued that lack of access to credit prevents farmers, particularly small farmers, from adopting profitable innovations requiring fixed (lumpy) investments. This will probably be the case where the adoption of divisible innovations (such as fertilizer-responsive MVs) depends on (or is greatly enhanced by) complementary indivisible investments (such as tractors, and tube wells) which require a large, initial investment.

In their stimulation of the impact of credit on Central Luzon rice farmers, Rosegrant and Herdt showed that the impact of fertilizer subsidies in the 1970s would have been higher if a larger quantity of credit were available. This does not, however, imply that credit needs to be subsidized through an artificial reduction in the interest rate. Repressed interest rates may constrain the flow of funds into rural financial markets, make it impossible to mobilize rural savings in substantial quantities, and induce lenders to concentrate cheap loans to wealthy borrowers (Tolentino, 1986; Adams 1988). The rural poor are thus ultimately penalized on both their loans and deposits by low repressed interest rates. Indeed, in the case of the Masagana-99 Program launched in the early 1970s to boost rice production, the credit subsidy tied with the program tended to favor large farmers and discriminated against small farmers who were the avowed major clientele of the credit subsidy program (Esguerra, 1981).

What Rosegrant and Herdt showed is that higher interest rates, if they attract substantially more funds into the rural financial markets, would be preferable to subsidized low interest rates and would not likely reduce fertilizer purchase and agricultural production significantly. Moreover, even if credit were subsidized, farmers would probably not utilize the credit to increase their usage of fertilizer. The frequent real reasons for farmers not seeking or obtaining credit are lack of knowledge and profitable investment opportunities (David *et al.,* 1984).

What is more crucial to agriculture is the availability of credit commensurate to its share of national income and employment, and not so much interest-rate reduction on credit. The Marcos government's agricultural credit policies, which provideds for loan quota schemes and which required commercial banks to provide loans to farmers at low interest rates set by the government, resulted in a decline in the flow of loanable funds into agriculture (Lamberte and Lim, 1987). Numerous cases of this experience have also been observed in other developing countries (Braverman and Guasch, 1986; Adams, 1988).

Farm Size and Land Tenure

In the development literature, it is often argued that farm size constrains the adoption of fertilizer-responsive modern varieties and, hence, the intensity of demand for modern inputs such as fertilizer. The arguments that have been presented are quite complex, and so is the empirical evidence to support or to dismiss these arguments (Feder *et al.,* 1985). The complexity arises from the fact that farm size is a surrogate for a large number of potentially important factors such as access to credit, capacity to bear risk, access to scarce inputs (water, seeds, fertilizer, insecticides), wealth, access to information, and so on. Since the importance of these factors varies in different areas and over time, so does the relationship between farm size, on the one hand, and adoption behavior and fertilizer use, on the other.

In Philippine agriculture, as in a number of other monsoon Asian agriculture, the accumulated empirical evidence points to a conclusion that, in general, the MV technology diffused widely among farmers, irrespective of farm size and land tenure, in areas where irrigation was available (Herdt, 1987; Barker and Herdt, 1985; Hayami, 1983; Ruttan 1977). Moreover, neither farm size nor land tenure has been found to be an important source of differential growth in productivity. While smaller farmers and tenants tended to lag behind larger ones in the early years following the introduction of the MV technology, these lags have typically disappeared within a few years. However, in areas where the social environment is characterized by extremely skewed distribution of wealth and power, this "catching up" may not occur (Hayami and Kikuchi, 1982).

On the other hand, short-term tenancy arrangments and the associated uncertainty about such arrangements in the future tend to reduce land-improving investments and fertilizer use. Because the benefits of investments in land development usually extend beyond one cropping season, these arrangements bring about uncertainty as to who will reap the benefits beyond the cropping season for which these investments were initially applied. This problem may also arise when the government makes policy pronouncements about the need for land reform and land redistribution in the near future. A reduction of this uncertainty may result in expanded usage of fertilizer and other land-improving measures.

Rural Infrastructure and Complementary Inputs

In what is perhaps a more complete analysis of the interactions of fertilizer use (and other inputs) and rural infrastructure and support services, Evenson (1986) showed that improvement in transport and extension services would have substantial positive impact on agricultural output and input use. In a cross-section analysis involving 66 countries, Antle (1983) also found the significant impact of infrastructure on agricultural productivity, with output elasticities with respect to infrastructure (specified as value of transport and communication services per square kilometer of land area) ranging from 0.20 to 0.37.

The high complementarity among fertilizer, modern varieties, irrigation, and support services is evident in the cross-country comparison of fertilizer use between the newly developed countries of East Asia and the developing countries of South and Southeast Asia. In East Asia, where high complementary inputs exist and where agricultural price policies are favorable to increased production, fertilizer application exceeds 200 kg/ha (Figure 3). This contrasts markedly with those prevailing in South and Southeast Asian countries where complementary inputs are low and where agricultural price policies tend to create disincentives to increase production. In these countries, fertilizer application is mostly less than 60 kg/ha.

Thus, it is misleading to suppose that a developing country like the Philippines needs only to, say, subsidize critical farm inputs such as fertilizer and/or outputs to achieve an increase in yield comparable to the yields prevailing in East Asian countries. That is, the response function Y (dashed line) in Figure 3 is irrelevant because it does not represent the actual situation in any given country. To move to the high yield-input level, complementary inputs, including rural infrastructure, and policies must all change along with fertilizer application rates.

4. Price Subsidization Alternatives

Policies providing for fertilizer (and credit) subsidies have been very common elements of the agricultural development strategies of many developing countries, including the Philippines. In many of these countries, expenditures on fertilizer subsidies have far exceeded

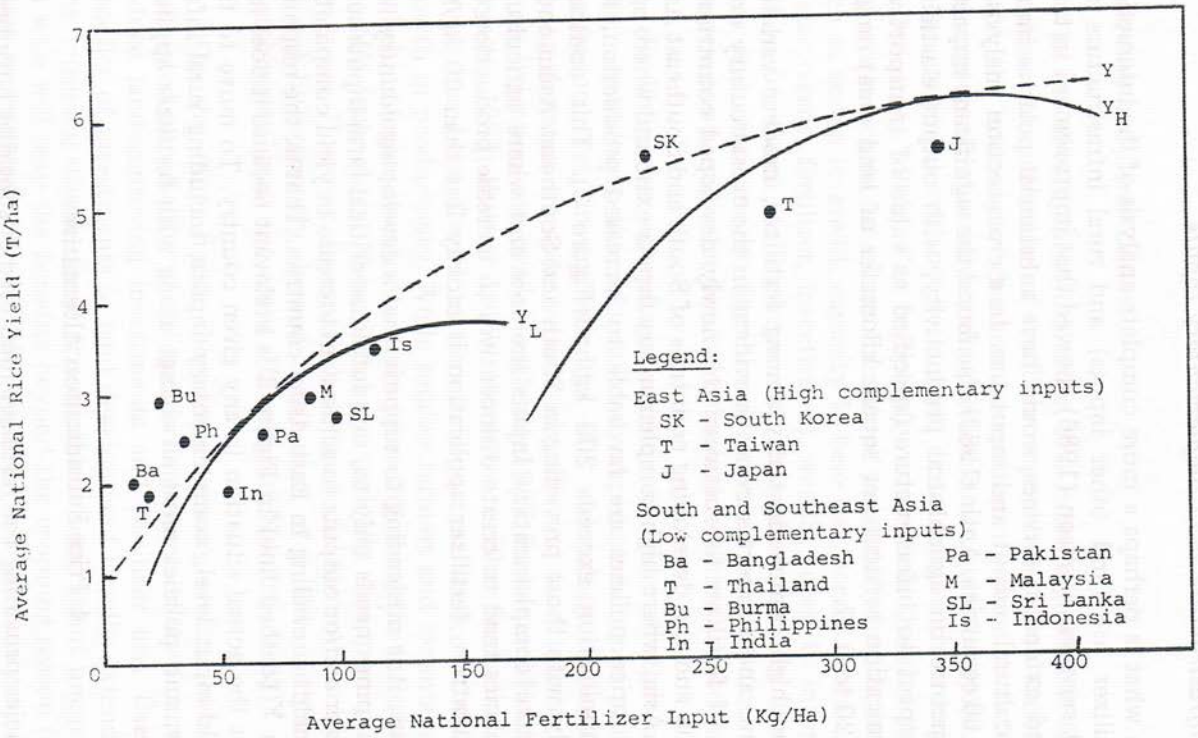

Figure 3 - A Stylized Set of Fertilizer Response Functions Contrasting East Asia with South and Southeast Asia

expenditures on agricultural research (Pinstrup-Andersen, 1982). In contrast, in many developed countries, there have been no fertilizer subsidies; among those that have, more of public funds are allocated to agricultural research compared with fertilizer subsidies. In the Philippines, fertilizer subsidies were about 148 percent of government expenditures on agricultural research during the 1976-81 period.[4] Thus, much larger public funds have been used to reduce the cost of existing technology (i.e., fertilizer) than to develop new technologies through agricultural research.

Notwithstanding the actual nature and incidence of fertilizer subsidies, it is worthwhile to examine the cases where fertilizer subsidies have been, rightly or wrongly, justified. In many developing countries, the more common justifications for fertilizer subsidies are: (1) to increase agricultural production, (2) to offset risk aversion of the farmers, and (3) to encourage the adoption of new technologies. In the Philippines, these justifications have likewise been the ones typically advanced by advocates of fertilizer subsidies.

Input Subsidies to Increase Agricultural Production

Increasing agricultural production has been the most common justification for input subsidies, particularly of fertilizer, among net importers of food in Asia and Sub-Saharan African countries. There are, however, other means of increasing agricultural production. Increasing the support price of output is one. Investments in agricultural research and in complementary agricultural infrastructure (e.g., irrigation) are another source of agricultural output growth.

One reason for the relatively stronger emphasis on fertilizer subsidies is that the time lag involved between government spending and the resulting production increase is shorter for fertilizer subsidies than that for investments in agricultural research and land improvement infrastructure. It is thus not difficult to understand why politicians (and government bureaucrats) whose typically high marginal rates of time preference favor programs and projects with short time

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[4] Much of the fertilizer subsidies in the Philippines did not accrue to farmers but rather to fertilizer importers cum local manufacturers (Balisacan, 1989). The prices paid by farmers for their fertilizers were, by and large, higher than what these prices would have been in the absence of regulatory policies on international trade and domestic distribution.

lags, find fertilizer subsidies as a convenient source of political mileage. Related to this is the fact that in many developing countries, food and agricultural problems are so urgent that government spending in projects or programs with short-term effects takes high priority, even though the long-term benefits may be lower than those obtainable from investments in agricultural research and rural infrastructure.

Between input price subsidies and output price support, the former tend to be more politically appealing in countries where a large share of the urban consumers' budget is spent on food, so that increases in the price of food (due to, for example, output price support) have significant and negative impact on their real incomes. In addition, higher food prices may contribute to higher inflation, lower growth, and political instability. In contrast, the costs of input subsidies on the individual consumer are not immediately obvious and can be distributed differently among consumer groups.

Given that both input price subsidies and output price support are politically and economically feasible instruments of public policy, under what circumstances is one more effective than the other? That is, to the extent that the government's objective is to achieve a given expansion of agricultural output (e.g., to achieve self-sufficiency), which of these instruments would be more cost-effective to the treasury? In a first-best world where market failures are absent and where government costs are met by non-distorting taxes, output subsidy has been conventionally shown to be more efficient than input subsidy in encouraging output expansion. The argument is that input subsidy does, and output subsidy does not, cause distortion on input choice away from the least-cost combination. However, in reality, the raising of funds to pay subsidies gives rise to inefficiency (deadweight) losses elsewhere in the economy. Thus, a policy instrument that is more cost-effective in stimulating output may well be the more economically efficient measure.

The issue of least-cost subsidization has been considered by a number of authors, including Barker and Hayami (1976), Parish and McLaren (1982), and Chambers (1985). Shalit and Binswanger (1985) and Quibria (1987) have reviewed earlier studies on cases for fertilizer subsidies. The general conclusion that emerged from these studies has been that input price subsidies tend to be more effective than output price support if (i) the supply of the subsidized input is elastic, (ii) the subsidized input is a substitute for production factors that are supplied inelastically, and (iii) the subsidized input is a poor substitute for production factors that have elastic supplies.

In countries or regions where cultivable land is scarce and inelastic in supply, fertilizers are a good substitute for land. Moreover, fertilizers complement (i.e., are poor substitutes for) most other inputs (e.g., labor) which have relatively elastic supplies. Also, in a small, open economy, the supply of fertilizer is perfectly elastic. Thus, all of the above conditions are likely met in many land-scarce developing countries, including the Philippines. Fertilizer subsidies are therefore likely more cost-effective to the government treasury than output price support.

The effectiveness of input subsidies in stimulating increases in agricultural production is greater when yield responses to inputs are high and the output supply is price inelastic (Barker and Hayami, 1976). In the case of fertilizer, high-yield responses are realized only when complementary inputs (e.g., irrigation and modern varieties) are adequately available. Otherwise, incremental increases in output can be achieved only at substantial costs.

Subsidies are, of course, not the only way to reduce input prices. These prices are affected by a number of factors such as the cost of local distribution, the competitiveness of the domestic input market, and even exchange rate and trade policies. Thus, improving the efficiency of local distribution, enhancing competition in the domestic input markets, and the lifting of counter-productive regulations, could lower input prices. The costs, for example, of fertilizer distribution in the Philippines are relatively high, representing about 40 percent of the retail cost. Also, in some areas, exploitation of the imperfections in the marketing system leads to unreasonably high profit margins among fertilizer traders, further raising fertilizer prices for the farmer.

Input Subsidies to Circumvent Risk Aversion

In many developing countries, fertilizer pricing policies have often been partly justified on account of production risk and uncertainty. That is, to the extent that agricultural production is highly uncertain and that risk aversion of farmers would lead to, say, fertilizer application rates lower than the socially optimal level, fertilizer subsidies are argued as an effective mechanism for correcting this "underinvestment" or resource-misallocation problem. The review of the literature in the preceding section, however, suggests that this argument is a rather weak case for fertilizer subsidies. While farmers are risk-averse, risk aversion can account for reductions of fertilizer use below profit-maximizing levels of only about 10 to 17 percent (Shalit and Binswanger, 1985). Where subsidies are justified based on this argument, the social costs, including the disruption that large fertilizer subsidies tend to cause in the distribution of fertilizer, may easily outweigh the gains from fertilizer subsidies.

Note that if expanded usage of inputs increases production variability, then it is possible that input subsidies can in fact lead to an increase in the variability of aggregate production and farm incomes. Such an increase, by itself, may not be desirable, and unless this can be offset at low cost by mechanisms such as international trade and public (or private) sector storage, the case for input subsidies on account of risk aversion may further weaken.

Input Subsidies to Promote the Adoption of New Technology

To promote the widespread adoption of fertilizer-responsive modern varieties has been another common argument for fertilizer subsidies in many developing countries. The core of this argument is that farmers who have not previously used fertilizer, or have used doses lower than what is optimal, may perceive production techniques using high doses of fertilizer as more risky than they really are. In this case, to compensate them for the perceived risk and thus induce them to adopt these techniques, it may be desirable to subsidize the use of fertilizer. Once farmers have learned the correct level of risk associated with these techniques, the subsidy can then be removed. In this context, fertilizer subsidies are temporary and are used only to speed up the adoption process or to overcome the problem of fixed costs related to the adoption of innovation (Hiebert, 1974; Feder *et al.,* 1985).

As noted earlier, while smaller farmers and tenants tended to lag behind larger farmers in the early years following the introduction of the modern rice technology, these lags eventually disappeared. These lags can be explained partly by the existence of fixed transaction costs and information acquisition costs associated with the new technology, differences in the degree of risk aversion between small and large farmers, and differential access to credit. The last one — access to credit — is particularly noted in many studies on adoption of agricultural innovations. It is argued that poor access to credit by small farmers inhibits early adoption of profitable innovations, particularly if lumpy investments are involved. In this case, fertilizer subsidies serve to ease the credit constraint, encourage the adoption of agricultural innovations and induce the learning process. But when enough time has been permitted for information gathering and diffusion, or when increases in farm incomes have been realized from the new technology, these subsidies may then have to be withdrawn.

The adoption argument suggests that temporary input subsidies must be instituted only when the technology is not yet widely diffused or only in specific areas where the adoption of technology is not yet complete. In the Philippines, the adoption of modern rice varieties is nearly completed, particularly in irrigated areas where the modern rice varieties have been most responsive. Thus, this argument for fertilizer subsidies is rather weak. Also, in practice, once subsidies are in place, it can be extremely diffficult to remove them when there is no longer a valid justification for their presence. Certain groups (perhaps even other than farmers) who have vested interests in input subsidies tend to lobby (exert political leverage) for the continuation of subsidies.

Moreover, it is extremely difficult (costly) to police the diversion of subsidized inputs such as fertilizers from targeted crops or regions to other crops or regions not covered by the subsidy program. Indeed, such diversion proved to be rampant when the two-tier fertilizer pricing scheme was in effect in the early 1960s and, again, in the early 1970s (Balisacan, 1989). This problem partly led to the subsequent termination of the program.

5. Conclusions

Pointed generalizations concerning the efficiency (or inefficiency) of resource use, the determinants of technology adoption, and the resource allocative effects of alternative price subsidization schemes in Philippine agriculture are limited partly because of wide differences in methodology and estimates found in the studies reviewed. Nonetheless, lessons can be learned from the materials covered by this survey. First , technical and managerial factors appear to represent nearly two thirds of the observed differences in yields among farms. One implication of this is that efforts aimed at raising farm incomes must pay attention to technological development and investments in human capital. That is, farmers are poor, not because they are allocatively inefficient, but because their resources (both in quality and quantity) and the technical and economic options available to them are restricted.

Second, far from the common presumption that farmers are unresponsive to price incentives, the available evidence indicates a reasonably strong response of farmers to price changes, provided new technologies and infrastructure are in place. This is borne out by the above estimates on the order of magnitude of the price elasticity of fertilizer demand. A similar conclusion has also been drawn with respect to agricultural supply response.[5]

Third, studies on peasants' risk aversion and technology adoption "suggest that the pure risk preferences of peasant farmers exhibit a surprising degree of cross-cultural homogeneity." That is, once payoffs exceed some trivial amounts, farmers' behavior tends to exhibit moderate to intermediate risk aversion, implying small differences in pure risk aversion among farmers. Also, increases in profit variability resulting from higher rates of fertilizer application have also been found to be relatively small, at least in irrigated or rainfed rice areas which were generally favorable production environments. These findings suggest that, contrary to popular belief, risk and risk aversion can account for only a small proportion of differences in fertilizer yields among farms. These results, however, should not be generalized to mean that they hold true regardless of production environments. From those studies conducted in the Philippines, the results were obtained from either irrigated areas or rainfed conditions in experimental stations, which are essentially favorable environments. Different results may be obtained from unfavorable environments, such as the flood-prone areas in the Bicol region or the drought-prone areas in the Ilocos region. In these areas, production conditions may be riskier. In rainfed farms, the occurrence of moisture stress is more frequent and its yield-reducing effect may increase with the application rate of, say, nitrogen fertilizer. This increase in risk can likely impede optimal input use, the extent of which remains the object of future research.

Fourth, available evidence indicates that neither farm size nor land tenure is an important source of differential growth in produc-

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[5] Although not reviewed here, studies on supply response to prices in Philippine agriculture are ample. These will be discussed in Part II of the survey. For a general survey of the literature in developing countries, see Rao (1989).

tivity. While smaller farmers and tenants tended to lag behind larger ones in the early years following the introduction of the MV technology, these lags have typically disappeared within a few years.

And fifth, studies in the Philippines and abroad suggest that the only strong case for input subsidies such as fertilizers is when the generally accepted goal of the government is to achieve a given expansion of agricultural output (e.g., to achieve food self-sufficiency or to replenish buffer stock). In this case, using fertilizer subsidies for highly responsive crops and in specific production areas where these crops are actually grown, are more cost-effective to the government than output subsidy. However, the pitfalls of input subsidies, discussed above, must be borne in mind. Also, one should not forget that improvements in fertilizer distribution, rural infrastructure (including interisland shipping facilities), and agricultural extension — apart from their being critical to overall agricultural transformation — are alternative ways of achieving the goals of either permanent or temporary fertilizer subsidies. At the very least, these must be considered in the design of public policies aimed to achieve agricultural output growth.

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