APPENDIX A
SOURCES OF DATA

The set of aggregate data consists of time series observations of rice production, inputs, and prices for 23 years (1950 through 1972) for 11 countries in Asia—Japan, Taiwan, South Korea, Sri Lanka, Indonesia, Thailand, Philippines, Burma, India, Pakistan, and Bangladesh. Pakistan and Bangladesh have been combined in the subsequent analysis because the data for the earlier period covered in our study cannot be separated by country.

Among the inputs used in rice production, only data on rice area and fertilizer consumption are consistently available in all countries. The available fertilizer data pertain to total consumption for all crops. The use of modified data to reflect fertilizer consumption in the rice sector alone did not change the substance of the analysis significantly, and hence only the statistical results based on the unadjusted fertilizer data have been presented. The annual data on fertilizer prices were the most difficult to collect. In the estimation of the fertilizer demand function where relaive fertilizer price is one of the arguments, a shorter time series was employed for Indonesia, Thailand, Burma, Pakistan, Bangladesh, and India because of lack of price data.

The major sources of the aggregate data are the series of *Production Yearbooks* and the *Annual Review of Fertilizers*, both published by the Food and Agriculture Organization of the United Nations. Individual country statistical studies are used when available. All the Japanese and Philippine data are obtained from the compilation recently prepared by M. Kikuchi, et al. and T. Anden, respectively, for the Stanford Rice Policy Project (7, 1). The fertilizer price data for Taiwan are those reported in the *Annual Taiwan Statistical Yearbook*. The data on the proportion of area planted to modern varieties are from Dalrymple's study (3).

The two other data sets utilized in this study are farm-level in nature. The first set is cross-village, cross-country farm data taken from the recent farm survey of 36 rice-growing villages in six Asian countries during the 1971-72 crop season. The time-series, cross-section farm data from the Laguna survey undertaken by IRRI since 1966 forms the second set.

In early 1971 a project, Changes in Asian Rice Farming, was initiated by a group of social scientists at IRRI and the University of the Philippines at Los Baños. The aim was to document the changes in production and production practices and in socio-economic factors such as income gain and sharing of benefits and employment related to the introduction of the modern varieties. In this connection, IRRI, the International Development Research Center, and 14 other Asian institutions jointly funded a two-round (wet and dry) farm survey of 36 villages in Asia which was undertaken by 30 Asian social scientists in six countries between late 1971 and early 1973. These villages were chosen from 14 study areas including five in India, two in Indonesia, one in Malaysia, one in Thailand, one in Pakistan, and four in the Philippines. Three of the villages were omitted from our analysis because fertilizer consumption was negligible.

More than 2,000 farmers were interviewed based on a random sample of 150 to 250 farms from one to three villages in each study area. At least one and usually all

of the villages in each study area had an adequate supply and control of water for producing two or more crops a year. In general, the villages selected are also characterized by easy physical access to the inputs required by the new technology and reasonably good access to markets for sale of produce. The areas included in the study, therefore, are not typical rice-farming areas but rather those favorably situated for the adoption of the new rice technology. The villages are, however, distributed over a broad geographic area reflecting substantial diversity in farming conditions as well as in quality of irrigation.

The survey contained village level information of the physical and economic environment in each study area and very extensive farm level data. Although a wide range of topics was covered, the data obtained are generally qualitative in nature except for rice production, cultivated area, fertilizer consumption, and prices of fertilizer and rice. Only a portion of the data collected in the Asian farm survey, i.e., those pertaining to the factors affecting fertilizer consumption, was used in this study.

The Laguna survey consists of a biannual series of farm surveys conducted by the Department of Agricultural Economics of IRRI during the wet and dry seasons between 1966 and 1973. Laguna is a rice-growing province in the Philippines located south of Manila. The respondents in this survey represent the more progressive rice farmers in the Philippines because of Laguna's proximity to Manila and well-developed roads and irrigation system. In addition, the presence of the College of Agriculture, University of the Philippines, and IRRI in Laguna has provided farmers with better access to developments of new technology in rice. Within three years after the introduction of the new seed-fertilizer technology in 1966, about three-fourths of the area in the sample was cultivated with modern varieties.

Although the scope of information obtained in the Laguna survey is narrower than that of the Asian survey, there is more quantitative data about farm production, inputs, prices, and farm practices. The 105 respondents (the actual number varied in each season) constituted a random sample from seven barrios in three municipalities of Laguna—Biñan, Cabuyao, and Calamba. The municipalities were selected principally on the basis of their differences in water resources. Biñan has gravity irrigation water available for only three crops in two years; Cabuyao farms are irrigated with lowlift pumps; and Calamba has year-round gravity irrigation.

Approximately 25 percent of the respondents are replaced each year in this series of surveys and the scope of the questionnaire has not been uniform in all the seasons. For example, labor data were collected during the 1970 wet and dry season, the 1971 dry season, and the 1973 wet-season surveys. The surveys in 1972 and 1973 covered only the farms in Biñan. For the sake of uniformity, our study has been based only on the wet-season surveys from 1966 to 1971.

APPENDIX B
EMPIRICAL MODELS

I. *Asian aggregate data*

$$\log f_{kt} = \log a + b_1 \log P_{kt} + c_1 M_{kt} + \sum_{2}^{11} a_k D_k \qquad (1)$$

$$+ \sum_{2}^{11} b_k (D_k \log P_{kt}) + u_{kt}$$

where

k = the country (= 1, 2, . . ., 11)
t = the year (= 1, 2, . . ., 23)
F = average fertilizer consumption in kilograms of nutrient per hectare
P = relative price of fertilizer to rice
M = proportion of area under modern varieties
D_k = intercept dummy variables where D_2 is equal to 1 for country 2 and 0 otherwise, D_3 is equal to 1 for country 3 and 0 otherwise, and so forth
$(D_k \log P_{kt})$ = slope dummy variables to distinguish intercountry differences in the price elasticity of demand
u = disturbance term

II. *Laguna farm survey*

$$\log F_{st} = \log a + b_1 \log P_{st} + c_1 M_{st} + e_1 \log V_{st} \qquad (2)$$

$$+ \sum_{2}^{6} a_t D_t + \sum_{2}^{6} b_t (D_t \log P_{st}) + u_{st}$$

where

s = the farm ($= 1, 2, \ldots n_t$)
t = the year ($= 1, 2, \ldots, 6$)
F = average fertilizer ocnsumption in kilograms of nitrogen per hectare
P = relative price of fertilizer to rice
M = proportion of area under modern varieties
V = value of production in P
D_t = intercept dummy variables where D_2 is equal to 1 for observations in year 1967 and 0 otherwise, D_3 is equal to 1 for year 1968 and 0 otherwise, and so forth
$(D_t \log P_{st})$ = slope dummy variables to distinguish interyear differences in the price elasticity of demand
u = disturbance term

III. *Asian farm survey*

$$\log F_{ij} = \log a + b_1 \log P_j + c_1 M_{ij} + c_2 \log N_j + c_3 R_j + c_4 \log W_j + e_1 \log V_{ij} + u_{ij} \qquad (3)$$

where

i = the farm $(= 1, 2, \ldots, n_j)$
j = the village (1, 2, . . ., 33)
F = average fertilizer use in kilograms of nutrients per hectare
P = relative price of fertilizer to rice
M = proportion of area under modern varieties
N = nitrogen input in kilogram per hectare needed to obtain maximum yield based on experimental response functions from experiment stations near village j
R = average proportion of rainfall for the two months prior to harvest (1967-71)
W = index of quality of irrigation (from 1-5) where 1 means well-irrigated and 5 means poorly irrigated or rainfed
V = value of production in $ per farm
u = disturbance term

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