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THE CONSEQUENCES OF SMALL RICE FARM MECHANIZATION PROJECT

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ANALYSIS OF THE DEMAND FOR FARM POWER FOR SMALL-RICE FARM AGRICULTURE IN NUEVA ECIJA, PHILIPPINES

By

Virgilio Monge
Bureau of Agricultural Economics, Philippines

and

Bart Duff
The International Rice Research Institute
Los Baños, Laguna

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ABSTRACT

The paper attempts to estimate the demand for tractor and power tiller services in Nueva Ecija, Philippines by examining rice farms using mechanized power alone or in combination with draft animals. Estimates of the demand for tractor and power tiller services were elastic which implies that exogenously enforced prices above the market determined rates would result in a substantial decrease in the employment of this input.

INTRODUCTION

Expanded use of tractors on Philippine farms began in the mid-60s, largely as a result of expanded credit programs to finance tractor purchases. During the 1970s there was increased interest in the use of both tractors and power tillers (Figure 1).

The role and adoption of farm power in Philippine agriculture has been examined in Barker, Myers, Crisostomo and Duff (1973) and Duff (1975). Other studies have investigated the growth and use patterns of power tillers and animal power on a wide range of farms (Alviar, 1974; Orcino and Duff, 1973; and Juarez and Duff, 1978). The factors affecting demand for mechanical power on rice farms, however, remain less clearly understood.

The analysis in this paper attempts to estimate the demand for tractor and power tiller services by examining rice farms using mechanical power alone or in combination with draft animals. This includes an analysis of (1) custom renting or that component of demand for tractor/power tiller services for farmers who rent-in machines to meet their power requirements, and (2) the demand for tractor services for farmers who are tractor/power tiller owners. The objective in examining these relationships is to assess the degree to which use of mechanical power in tillage operations is affected by economic, technical and environmental conditions. A complementary objective is to provide an empirical basis for the formulation and implementation of policy measures. For example, to what extent does the level of farm wages affect the demand for mechanical power? Given the shift of agriculture away from the traditional techniques of land preparation (such as the water buffalo), what is the substitutability of machines for animals?

The analysis begins with simple diagramatic relationship illustrating the factors which influence tractor and power tiller use in rice production. Using data generated by a stratified random survey of farmers, a regression model is used to analyze the effects of selected factors on tractor and power tiller use.

A FRAMEWORK OF ANALYSIS

Mechanical power is a derived demand. Machine services are an input in the rice production system and the demand for this input is derived from the demand for the end product (rice), interacting through the production function and the supply conditions for other factors. Figure 2, adapted from Gemmill and Eicher (1973) shows the conceptual

framework within which farm level demand for machine services may be analyzed. Consider a set of farmers who are tractor users. Given their initial resources, the prices of these resources and the ways in which they are distributed, farmers choose the most economic mix of technology (including tractor use), crop mix and the labor to be employed. These decisions determine the level of output and the level of machine services. The latter comprises the farmer's demand for tractor services. There are two important components of demand. The farmer may own a tractor or power tiller from which he draws his power requirements or he may hire from others to satisfy this demand. The former is designated as the tractor's owners demand and the latter the rental demand. Together, they comprise the total demand for tractor/power tiller services (flow).

Previous studies of the demand for tractors have been conducted by Cromarty (1959), Griliches (1960), Heady and Tweeten (1963), Fox (1966) and Rayner and Cowling (1967). These studies estimated demand elasticities for tractor stocks rather than the flow of tractor services.[1/] They do, however, provide useful insights regarding factors affecting the demand for tractor services. For example, Griliches has suggested that, using the assumptions of a given production function, competitive product and factor markets and profit maximization, the demand for tractor services depends on input prices, prices of inputs that are close substitute or complements, the rate of interest and similar economic variables.

In this paper the demand for power is estimated as a flow rather than a stock, using the profit function formulation of Lau and Yotopoulos (1973).

THE MODELS

Given a production function of the form:

$$Y = ae^{\gamma D} \prod_i X_i^{\alpha_i} \prod_j Z_j^{\beta_j} e^{u}; \quad \begin{matrix} i = 1, \ldots\ldots m \\ j = 1, \ldots\ldots k \end{matrix} \qquad (1)$$

where Y is output, the X_i's are variable inputs, the Z_i's are fixed inputs, D is a dummy variable and U is the disturbance term. The parameters of the model to be estimated are a, α_i, β_i and γ.

Given this production function, Henderson and Quandt, (1972) (for the two-input case) and Alcantara and Prato, (1973) (for the multi-input case) have shown that the demand for an input, e.g. machine services, is expressed as:

[1/] For a thorough discussion of stock and flow, see Yotopoulos (1967).

$$X_1 = g(P_{x_1}, Z_j, e^D, e^U); \; i = 2, \ldots, m \quad j = 1, \ldots, k \tag{2}$$

where X_1 is machine services and P_{x_i}'s are the variable input prices.

Lau and Yotopoulos (1973), Diewart (1973) and Yotopoulos, Lau and Lin (1976) have shown that the production function specified in equation (1) shows correspondence with the normalized and restricted profit function (π^*). The restricted profit function for each farm is defined as total revenue (product of total output and output price) less the total variable costs normalized by the output price as:

$$\pi^* = g(C_i, Z_j, D); \text{ where } i = 1, \ldots, m \quad j = 1, \ldots, k \tag{3}$$

where $C_i = P_{xi}/P_y$ and π/P_y. Following Lau and Yotopoulos, the demand functions for the variable inputs are obtained by differentiating the normalized profit function (equation 2) with respect to normalized variable input prices as:

$$-X_i = \partial\pi^*/\partial C_i \; ; \; i = 1, \ldots, m \tag{4}$$

Again, Lau and Yotopoulos have shown that, from the production function specified in equation (1), the estimating equation for profit function is:

$$\ln \pi^* = \ln a^* + \alpha_i^* \sum_{i=1}^{m} C_i + \beta_j^* \sum_{j=1}^{k} Z_i + \gamma D \tag{5}$$

Using Zellner's method[1/], the unbiased nature of the parameters to be estimated is further enhanced if the profit function is jointly estimated with the input demand functions given by:

$$-X_i \, C_i/\pi^* = \alpha_i^* \; ; \quad i = 1, \ldots, m \tag{6}$$

One important feature of equations (5) and (6) is that the parameters for the variable inputs in the profit function are equal to the parameters of the input demand functions if the farm firms behave according to some decision rules, e.g. profit maximizing given the output, input prices and the quantities of the fixed inputs. Given

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[1/] Directly estimating the demand for machine using OLS will result in inconsistent estimations of the structural parameters. Using Zellner method, however, this problem is avoided (Zellner, 1962).

this assumption, Lau and Yotopoulos have shown that the parameters (α_i*) for the variable inputs and the β_i*'s for the fixed inputs are related to the coefficients of the Cobb-Douglas production function as:

$$\alpha_i^* = -\alpha_i(1-\mu)^{-1} < 0; \quad i = 1, \ldots .m \quad \text{and } \mu = \Sigma\alpha_i \tag{7}$$

$$\beta_j^* = \beta_j(1-\mu)^{-1} > 0; \quad j = 1. \ldots ,k \tag{8}$$

(1), (2), (5) and (6) are the estimating equations. Equation (1) is the Cobb-Douglas production function wherein the demand for tractor/ power tiller services can be estimated. Equation (2) shows the equation directly estimating the demand for tractor or power tiller services and equations (5) and (6) the profit and input demand functions. For statistical purposes we assume that the disturbance term for equations (1) and (2) are normally and independently distributed with zero mean and constant variance. For the profit and input demand functions, we assume additive errors with zero mean and finite variance for equations (5) and (6). The covariance of the errors of the two equations for the same farm may not be zero but the covariance of the errors of either equation corresponding to different farms are assumed to be zero. With these assumptions an asymptotically efficient method of estimation, as suggested by Zellner, is employed to estimate the parameters of equations (5) and (6) simultaneously.

THE VARIABLES AND THE DATA

The variables used are as follows:

X_1 is a machine services measured in terms of horsepower-hours for two cropping seasons for each farm.

X_2 is man-labor days for two cropping seasons for each farm

X_3 is man-animal labor days for two cropping seasons for each farm

X_4 is kilograms of fertilizer used expressed in nutrients.

Z_1 is hectares of land used in rice production for two-cropping seasons

Z_2 is the total cost of capital services in rice production per farm for one crop year.[2/]

Z_3 is educational attainment of the farm operator expressed in the number of years spent in school

Z_4 is the number of years using tractor/power tiller

Z_5 is the number of years engaged in farming

P_{x_1} is hourly rental costs for each farm for tractor/power tiller services.[3/]

P_{x_2} is the average daily wage rate (8-hour equivalent)

P_{x_3} is the average daily rental rate for man-animal input.[4/]

P_{x_4} is the price of fertilizer per kilogram of nutrients

C_1 is hourly rental costs or price of machine services normalized by the price of output

C_2 is money wage per man-day in pesos normalized by the output price

C_3 is money wage for man-animal in pesos normalized by output price

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[2/] An annualized flow measure of capital services was derived for tractor/power tiller and each non-tractor/power tiller capital asset used in rice production. Included was depreciation, interest and operating costs. Depreciation was determined using straight line method, interest was computed at 10 per cent per annum. Operating costs include expenses for seeds, chemicals plus land tax and irrigation fee.

[3/] Included are the rental rate, the costs of meals, gasoline and cigarettes (for hiring farms), the costs of maintaining the machine, fuel, oil, and hired labor for repairs and operating the machine (for tractor/power tiller owners).

[4/] The rental cost of man-animal was determined for each non-animal owning farm. This includes the rental costs, the costs of meals and other costs, e.g. cigarettes, liquor for animal-owning farms. The cost of maintaining work animals was also determined. Included were the costs of feed, medicine, ropes, veterinary fees and hired labor.

C_4 is price of fertilizer per kilogram of nutrient normalized by the output price.

Y is output measured in cavans (50 kgs./cavan)

π is profit or total revenue (product of total output and output price) less the variable costs in pesos.

The basic farm-level data used in the study was gathered from 177 rice farms (using tractor or power tiller with supplemental draft animal power) through random survey spread over eight villages in Nueva Ecija, Philippines (Fig. 3). The design and data collection were supervised by the authors. The data have been used earlier in Monge (1980).

Four farm types were included in the study:

1) tractor owning farms -- farmer who owns a four-wheel tractor(s).
2) tractor renting farms -- farmer renting four-wheel tractor(s)
3) power tiller owning farms -- farmer who owns a power tiller (two-wheel tractor)
4) power tiller renting farms -- farmer renting power tiller(s)

One must bear in mind some major difficulties in conducting econometric demand studies based on cross-sectional data.

The first is variability. Demand studies using cross-sectional data generally contain only current input and output prices. These prices usually embody only limited variability and much of the observed difference may not be genuine, i.e. the prices do not accurately reflect relative factor scarcities. To use prices in demand function estimates a minimum coefficient of variation, usually 20 percent[5/] is necessary to permit observation of the effect of change in one variable on other variables.

A second difficulty is the specification and simultaneous equation issue. The quantities of inputs used by farmers are not determined solely by the farmer, but also by the supplier, e.g. the availability of machine power at the time the farmer needs it. Under competitive conditions, the amount of machine power employed and the quantity supplied will determine the rental rates for machine power. This rate in turn will affect both demand and supply. Directly estimating the demand for machine power using OLS will result in consistent estimations of the structural parameters. One method to overcome this problem is to estimate demand for machine power indirectly using the profit function approach employed by Lau and Yotopoulos (1973). Again, output and input prices should demonstrate sufficient variation to permit reliable estimates to be made.

[5/] Dr. H.P. Binswanger (personal communication).

Finally, in all of the models specified no attempt has been made to incorporate land quality. This has a direct effect on land productivity and hence on the level of inputs used. If land quality and use of machine power are highly correlated, the effect of omitting land quality will be captured by the machine power variable.

CHARACTERISTICS OF THE SAMPLE FARMS

The characteristics of the sample farms are shown on Table 1. Machine owners had longer experience in both farming and use of machinery than renters. Tractor owners had more years of schooling than renters but power tiller owners had less education than power tiller renters. Farms also differ significantly in size. Fifty percent of the power tiller owners and almost one-half of the renters were lessees. The majority of all farmers were members of the local Samahang Nayon (village organization).

Machine renters reported a slightly higher cropping intensity (190.4% for power tillers and 186.5% for tractors) than owners (177.7% for power tillers and 174.1% for tractors).

RESULTS

The result of simultaneously estimating the profit and input demand functions are shown on Tables 2 and 3 and the derived production elasticities as specified in equations (7) and (8) are on Table 4.[6]

The magnitude of the estimated production elasticities (both from the production function and profit function) for machine services was negligible.

The elasticities of demand of the other variable inputs exhibited the expected signs indicating consistency with economic theory. The cross-price elasticities of the variable inputs included in the model showed negative signs, indicating the complementary relationships of these inputs. In addition, the own-price elasticity of machine services and all of the variable inputs are all greater than unity in absolute value indicating elastic response in factor utilization.

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[6] Alternative estimates (both direct and indirect) for production elasticities were also done. These are reported in Monge (1980).

The effect of the output price on output supply and on the variable inputs were also derived. These are shown on Table 5 for tractor and Table 6 for power tiller users. The result shows that the output supply and input demand appears to be sensitive to changes in output price. However, output appear to be less sensitive to change in the price of machine services, confirming the results earlier that output is not responsive to tractor/power tiller services.

The variables included in the models that contribute to the accumulation of information such as the number of years using tractor/ power tiller, number of years engaged in farming and village organization appeared to be invariant for all farm groups, indicating little influences of these variables in the use of machines.

CONCLUSIONS AND POLICY IMPLICATIONS

There are two major conclusions from the analysis. First, the estimates of demand for inputs such as man-labor, man-machine labor, man-animal combination and fertilizer were elastic. This means that exogenously enforced prices above the market determined rates would result in a substantial decrease in the employment of these inputs. The effect of the current increasing energy cost on the employment of this input is obvious , e.g., price of oil will further push up rental costs which implies a lower employment of this input. Second, the impact of equal percentage change in the prices of machine and prices of output on the employment of tractor/power tiller services are not equal. The price of rice appears to be a much more powerful policy tool than the price of machine services to influence employment of tractor/power tiller services in rice production and increasing rice output. Contrary to the previous result (Barker and Hayami, 1976), who argued in favor of input subsidy (e.g. fertilizer) rather than output price support, our findings showed that output price is a more powerful policy instrument. Our findings are consistent with Krishna (1967) and Sidhu and Baanante (1979) who favor output price support rather than input subsidy for accelerating growth of agricultural output in developing economies.

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Table 1. General characteristics of sample farms, 177 farmers, Nueva Ecija, 1978.

	Power tiller				Tractor			
	Owners[a]		Renters		Owners[a]		Renters	
Number of farms	38		46		30		63	
Average age (years)	51.6		46.4		49.4		44.7	
Educational attainment[b]	4.4		5.7		7.7		5.4	
Number of years engaged in farming	32.3		25.4		26.5		21.9	
Number of years using tractor	4.9		4.4		7.2		5.8	
Average farm size (hectares)	3.1		2.3		6.6		2.6	
	No.	%	No.	%	No.	%	No.	%
Tenure								
Owner	5	13.2	6	13.3	18	60.0	8	12.5
Amortizing owner	7	18.4	13	28.9	2	6.7	14	21.9
Share-tenant	5	13.2	3	6.7	-	-	1	1.6
Lessee	19	50.0	21	46.7	7	23.3	39	60.9
Others[c]	2	5.2	2	4.4	3	10.0	2	3.1
Samahang Nayon (Village Organization)								
Member	30	79.0	31	68.9	21	70.0	53	82.8
Non-member	8	21.0	14	31.1	9	30.0	11	17.2
Sources of water								
Gravity	34	89.6	43	95.6	24	80.0	60	93.8
Pump	1	2.6	-	-	1	3.3	-	-
Gravity/pump	1	2.6	-	-	2	6.7	1	1.6
Rain	1	2.6	1	2.2	1	3.3	-	-
Gravity/rain	1	2.6	1	2.2	2	6.7	3	4.6
Cropping intensity (percentage)[d]	-	177.7	-	190.4	-	174.1	-	186.5

a/ Some 26.3 percent of the power tiller owners and 56.7 percent of the tractor owners are engaged in contract work.
b/ Average number of years spent in school.
c/ Combination.
d/ Cropping intensity = Cropped area/yr x 100/arable farm area

Table 2. Results of joint estimation of Cobb-Douglas profit function and input demand functions, crop year 1977-78, Nueva Ecija.

Profit function	Parameters	Power tillers				Tractor			
		Owner		Renters		Owner		Renters	
		Single equation OLS	Zellner's method	Single equation OLS	Zellner's method	Single equation OLS	Zellner's method	Single equation OLS	Zellner's method
Constant	a^*	5.40 (2.14)	6.78 (1.29)	3.98 (1.36)	6.46 (0.77)	8.69 (5.98)	9.95 (2.72)	4.60 (1.35)	5.87 (0.47)
Man-machine labor	α_1^*	-0.17* (0.09)	-0.09 (0.02)	-0.01 (0.16)	-0.01 (0.02)	0.20 (0.21)	-0.08 (0.08)	0.08 (0.11)	-0.03 (0.00)
Man-labor	α_2^*	0.71** (0.32)	-0.12 (0.02)	-0.03 (0.26)	-0.11 (0.02)	-0.29 (1.11)	-0.08 (0.12)	0.48 ** (0.23)	-0.14 (0.01)
Man-animal labor	α_3^*	-0.01 (0.08)	-0.03 (0.02)	-0.06 (0.10)	-0.02 (0.01)	0.23 (0.24)	-0.11 (0.06)	0.03 (0.11)	-0.14 (0.01)
Fertilizer	α_4^*	0.17 (0.62)	-0.16 (0.02)	1.58** (0.60)	-0.13 (0.02)	-1.38** (1.56)	-0.07 (0.09)	0.52 (0.50)	-0.13 (0.01)
Land	β_1^*	0.88*** (0.19)	0.75 (0.14)	0.16 (0.39)	+0.22 (0.19)	0.90** (0.40)	0.90 (0.19)	0.88 *** (0.15)	0.83 (0.08)
Capital	β_2^*	0.20 (0.22)	0.19 (0.14)	0.31 (0.20)	0.22 (0.12)	0.07 (0.57)	-0.24 (0.28)	0.15 (0.14)	0.14 (0.07)
Education	β_3^*	-0.01 (0.11)	-0.05 (0.08)	0.11 (0.12)	0.01 (0.07)	0.07 (0.39)	-0.04 (0.18)	0.08 (0.09)	0.01 (0.04)
No. of years using machine	β_4^*	-0.04 (0.08)	-0.02 (0.07)	0.13 (0.10)	-0.04 (0.06)	0.01 (0.32)	0.03 (0.18)	0.04 (0.10)	-0.01 (0.05)
No. of years engaged in farming	β_5^*	-0.09 (0.16)	-0.09 (0.13)	0.11 (0.10)	0.07 (0.06)	-0.17 (0.39)	-0.09 (0.19)	0.01 (0.11)	0.09 (0.05)
Village organization dummy	α	-0.29 (0.21)	-0.22 (0.16)	0.08 (0.17)	0.05 (0.11)	-0.01 (0.48)	-0.16 (0.24)	-0.14 (0.15)	-0.05 (0.08)
R^2		0.70		0.50		0.54		0.70	
Demand Functions									
Man-machine labor			-0.09 (0.01)		-0.01 (0.02)		-0.08 (0.07)		-0.03 (0.00)
Man-labor			-0.12 (0.01)		-0.11 (0.01)		-0.08 (0.10)		-0.14 (0.01)
Animal labor			-0.03 (0.02)		-0.02 (0.01)		-0.11 (0.04)		-0.14 (0.01)
Fertilizer			-0.16 (0.02)		-0.13 (0.02)		-0.07 (0.07)		-0.13 (0.01)

Note: Figures in parentheses are standard errors for OLS and asymptotic standard errors for Zellner's method.

Restriction on Zellner's method: $\alpha_1^* = \alpha_1^*$; $\alpha_2^* = \alpha_2^*$; $\alpha_3^* = \alpha_3^*$; $\alpha_4^* = \alpha_4^*$. In each equality restrictions, the α_1^* on the left side of the equation belong to the profit function and the α_1^* on the right side, is the input demand functions.

Table 3. Results of joint estimation of Cobb-Douglas profit function and input demand functions: Crop year 1977-78, Nueva Ecija.

Profit functions	Parameters	Power tiller				Tractor			
		Single equation (OLS)	Zellner's Method			Single equation (OLS)	Zellner's Method		
			Unrestricted	Restriction 1/	Restriction 2/		Unrestricted	Restriction 1/	Restriction
Constant	a^*	4.21 (1.03)	6.83 (0.70)	5.50 (0.44)	5.64 (0.47)	6.82 * (1.40)	6.46 (0.94)	6.24 (0.49)	6.26 (0.49)
Man-machine labor	α_1^*	0.16 (0.07)	-0.09 (0.05)	-0.05 (0.01)	-0.05 (0.11)	-0.17 (0.08)	0.03 (0.06)	-0.08 (0.03)	-0.07 (0.03)
Man-labor	α_2^*	0.42 (0.20)	-0.30 (0.13)	-0.12 (0.01)	-0.12 (0.01)	-0.31 (0.29)	0.33 (0.20)	-0.19 (0.04)	-0.19 (0.04)
Man-animal labor	α_3^*	0.01 (0.06)	-0.00 (0.04)	-0.03 (0.04)	-0.03 (0.01)	0.12 (0.10)	0.13 (0.07)	-0.16 (0.02)	-0.16 (0.02)
Fertilizer	α_4^*	0.93 (0.40)	-0.39 (0.27)	-0.15 (0.01)	-0.15 (0.01)	-0.09 (0.56)	-0.06 (0.38)	-0.16 (0.03)	-0.16 (0.03)
Land	β_1^*	0.61 *** (0.16)	0.62 (0.11)	0.71 (0.06)	0.64 (0.10)	0.99 (0.14)	0.83 (0.09)	0.95 (0.05)	0.84 (0.08)
Capital	β_2^*	0.29 (0.10)	0.19 (0.07)	0.29 (0.06)	0.28 (0.06)	0.08 (0.09)	0.06 (0.06)	0.05 (0.05)	0.05 (0.05)
Education	β_3^*	-0.00 (0.08)	0.03 (0.05)	0.02 (0.05)	-0.02 (0.05)	0.08 (0.11)	0.04 (0.07)	-0.01 (0.06)	0.03 (0.07)
No. of years using tractor/power tiller	β_4^*	0.02 (0.06)	-0.00 (0.04)	-0.00 (0.04)	-0.00 (0.04)	0.01 (0.11)	0.04 (0.07)	0.05 (0.07)	0.04 (0.07)
No. of years engaged in farming	β_5^*	0.06 (0.08)	0.04 (0.06)	0.02 (0.05)	0.04 (0.06)	0.01 (0.12)	-0.02 (0.08)	-0.06 (0.07)	-0.01 (0.08)
Village organization dummy	α	-0.16 (0.14)	-0.11 (0.09)	-0.21 (0.09)	-0.20 (0.09)	-0.16 (0.17)	-0.10 (0.11)	-0.08 (0.11)	-0.11 (0.11)
		0.53				0.59			
Demand Functions									
Man-machine labor	α_1^*	0.11 (0.03)	-0.06 (0.01)	-0.05 (0.01)	-0.05 (0.01)	0.17 (0.14)	-0.09 (0.03)	-0.08 (0.03)	-0.07 (0.03)
Man-labor	α_2^*	-0.02 (0.08)	-0.12 (0.01)	-0.12 (0.01)	0.12 (0.01)	0.38 (0.46)	-0.19 (0.04)	-0.19 (0.04)	-0.19 (0.04)
Man-animal	α_3^*	-0.29 (0.02)	-0.04 (0.01)	-0.03 (0.01)	0.03 (0.01)	0.05 (0.08)	-0.16 (0.02)	-0.16 (0.02)	-0.16 (0.02)
Fertilizer	α_4^*	-0.25 (0.10)	-0.16 (0.01)	-0.15 (0.01)	0.15 (0.01)	0.12 (0.34)	-0.16 (0.03)	-0.16 (0.03)	-0.16 (0.03)

Note 1: Figures in parentheses are standard errors for OLS and asymptotic standard errors for Zellner's method.

Restrictions:

1/ $\alpha_1^* = \alpha_1^*$; $\alpha_2^* = \alpha_2^*$; $\alpha_3^* = \alpha_3^*$; $\alpha_4^* = \alpha_4^*$; $\beta_1^* + \beta_2^* = 1$

2/ $\alpha_1^* = \alpha_1^*$; $\alpha_2^* = \alpha_2^*$; $\alpha_3^* = \alpha_3^*$; $\alpha_4^* = \alpha_4^*$

Table 4. Production elasticities derived from profit and input demand functions.

Inputs	Power tiller			Tractor		
	Owners	Renters	All farms	Owners	Renters	All farms
Man-machine labor	0.07	0.01	0.03	0.06	0.02	0.05
Man-labor	0.08	0.08	0.09	0.06	0.10	0.12
Man-animal labor	0.02	0.02	0.02	0.08	0.09	0.10
Fertilizer	0.11	0.10	0.11	0.06	0.09	0.08
Land	0.53	-0.18	0.48	0.66	0.58	0.53
Capital	-0.14	0.17	0.21	-0.18	0.09	0.03
Education	-0.04	0.01	-0.01	-0.03	0.01	0.02
No. of years using machine	-0.02	0.03	-0.00	0.02	-0.01	0.02
No. of years engaged in farming	-0.06	0.06	0.03	-0.07	0.06	-0.01
Village organization dummy	-0.17	0.04	-0.15	-0.12	-0.04	-0.07

Note: Estimated by equations (7) and (8).

Table 5. Own and cross-price elasticities of variable inputs and elasticities with respect to fixed inputs, education experience in farming and using machine and village organization for tractor users.

Items	Rice Supply			Man-machine labor			Man-labor			Man-animal			Fertilizer		
	Owners	Renters	All farms	Owners	Renters	All farms	Owners	Renters	All farms	Owners	Renters	All farms	Owners	Renters	All farmers
Price of rice	0.35	0.44	0.58	1.35	1.44	1.58	1.35	1.44	1.58	1.35	1.44	1.58	1.35	1.44	1.58
Price of man-machine labor	0.08	0.03	0.07	-1.08	-1.03	-1.07	-0.08	-0.03	-0.07	-0.08	-0.03	-0.07	-0.08	-0.03	-0.07
Price of man-labor	0.09	0.14	0.19	-0.09	-0.14	-0.19	-1.09	-1.14	-1.19	-0.09	-0.14	-0.19	-0.09	-0.14	-0.19
Price of man-animal labor	0.11	0.14	0.15	-0.11	-0.14	-0.15	-0.11	-0.14	-0.15	-1.11	-1.14	-1.15	-0.11	-0.14	-0.15
Price of fertilizer	0.07	0.13	0.16	-0.07	-0.13	-0.16	-0.07	-0.13	-0.16	-0.07	-0.13	-0.16	-1.07	-1.13	-1.16
Land	0.89	0.83	0.84	0.89	0.83	0.84	0.89	0.83	0.84	0.89	0.83	0.84	0.89	0.83	0.84
Capital	-0.24	0.13	0.05	-0.24	0.13	0.05	-0.24	0.13	0.05	-0.24	0.13	0.05	-0.24	0.13	0.05
Education	-0.04	0.01	0.03	-0.04	0.01	0.03	-0.04	0.01	0.03	-0.04	0.01	0.03	-0.04	0.01	0.03
No. of years using tractor/power tiller	-0.03	-0.01	0.04	-0.03	-0.01	0.04	-0.03	-0.01	0.04	-0.03	-0.01	0.04	-0.03	-0.01	0.04
No. of years engaged in farming	-0.09	0.09	-0.01	-0.09	0.09	-0.01	-0.09	0.09	-0.01	-0.09	0.09	-0.01	-0.09	0.09	-0.01
Village organization dummy	0.16	0.05	-0.11	0.16	0.05	-0.11	0.16	0.05	-0.11	0.16	0.05	-0.11	0.16	0.05	-0.11

Note: For owners and renters elasticities were derived from Table 8 and for all farms from Table 7.

Table 6. Own and cross-price elasticities of variable inputs and elasticities with respect to fixed inputs, educational experience in farming and using machine and village organization for power tiller users.

Items	Rice Supply			Man-machine labor			Man-labor			Man-animal			Fertilizer		
	Owners	Renters	All farms	Owners	Renters	All farms	Owners	Renters	All farms	Owners	Renters	All farms	Owners	Renters	All farms
Price of rice	0.40	0.27	0.34	1.40	1.27	1.34	1.40	1.27	1.34	1.40	1.27	1.34	1.40	1.27	1.34
Price of man-machine labor	0.09	0.01	0.05	-1.09	-1.01	-1.05	-0.09	-0.01	-0.05	-0.09	-0.01	-0.05	-0.09	-0.01	-0.05
Price of man-labor	0.12	0.11	0.12	-0.12	-0.11	-0.12	1.12	-1.11	-1.12	-0.12	-0.11	-0.12	-0.12	-0.11	-0.12
Price of man-animal labor	0.03	0.02	0.03	-0.03	-0.02	-0.03	-0.03	-0.02	-0.03	-1.03	-1.02	-1.03	-0.03	-0.02	0.03
Price of fertilizer	0.16	0.13	0.15	-0.16	-0.13	-0.15	-0.16	-0.13	-0.15	-0.16	-0.13	-0.15	-1.16	-1.13	-1.15
Land	0.75	0.22	0.64	0.75	0.22	0.64	0.75	0.22	0.64	0.75	0.22	0.64	0.75	0.22	0.64
Capital	0.19	0.22	0.28	0.19	0.22	0.28	0.19	0.22	0.28	0.19	0.22	0.28	0.19	0.22	0.28
Education	-0.05	0.01	0.02	-0.05	0.01	0.02	-0.05	0.01	0.02	-0.05	0.01	0.02	-0.05	0.01	0.02
No. of years using tractor	-0.02	-0.03	-0.00	-0.02	-0.03	-0.00	-0.02	-0.03	-0.00	-0.02	-0.03	-0.00	-0.02	-0.03	-0.00
No. of years engaged in farming	-0.09	0.07	0.03	-0.09	0.07	0.03	-0.09	0.07	0.03	-0.09	0.07	0.03	-0.09	0.07	0.03
Village organization	-0.22	0.05	-0.20	-0.22	0.05	-0.20	-0.22	0.05	-0.20	-0.22	0.05	-0.20	-0.22	0.05	-0.20

Note: For owners and renters elasticities were derived from Table 8 and for all farms from Table 7.

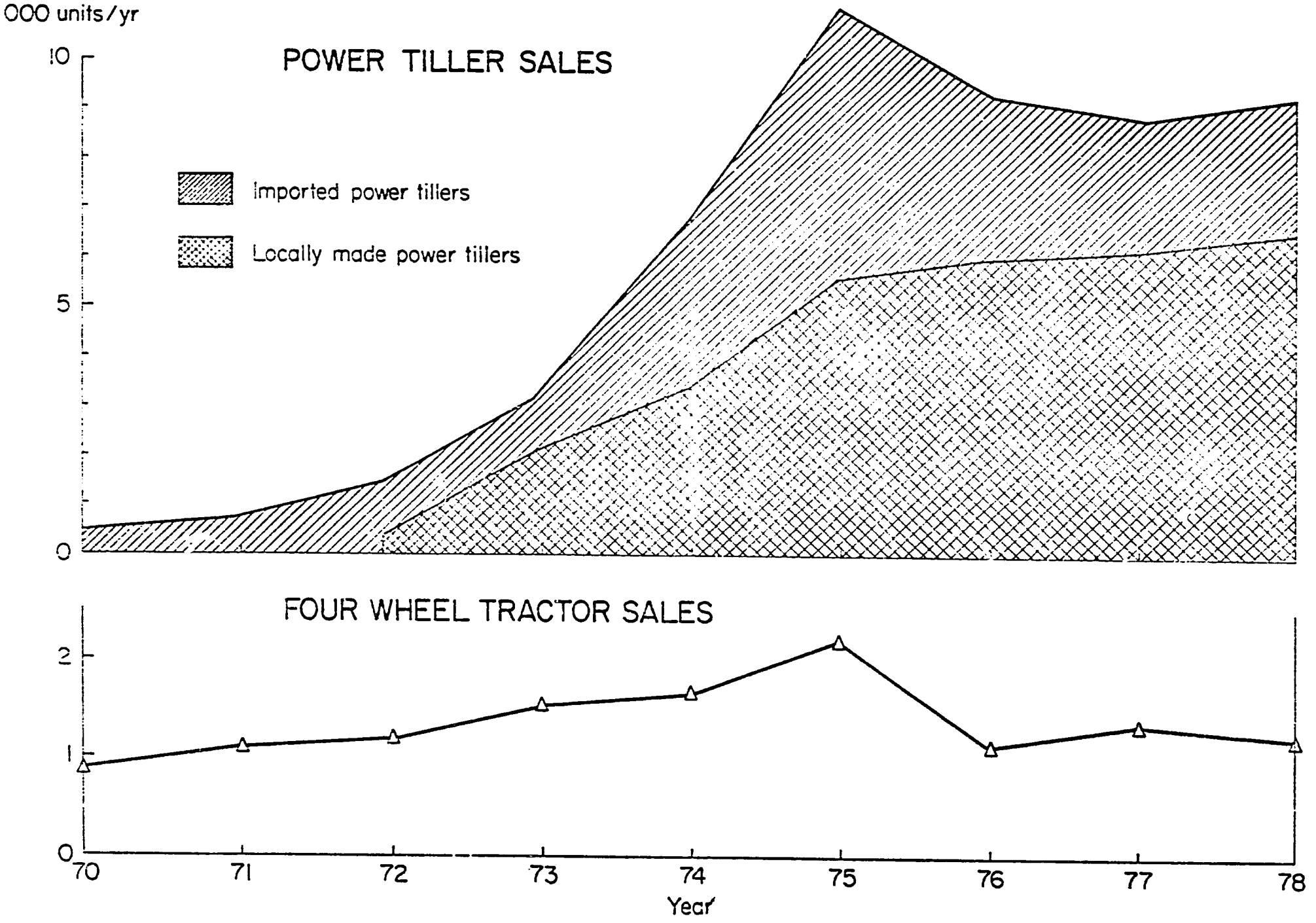

Fig.1. Four wheel tractor and power tiller sales in the Philippines, 1970-78.

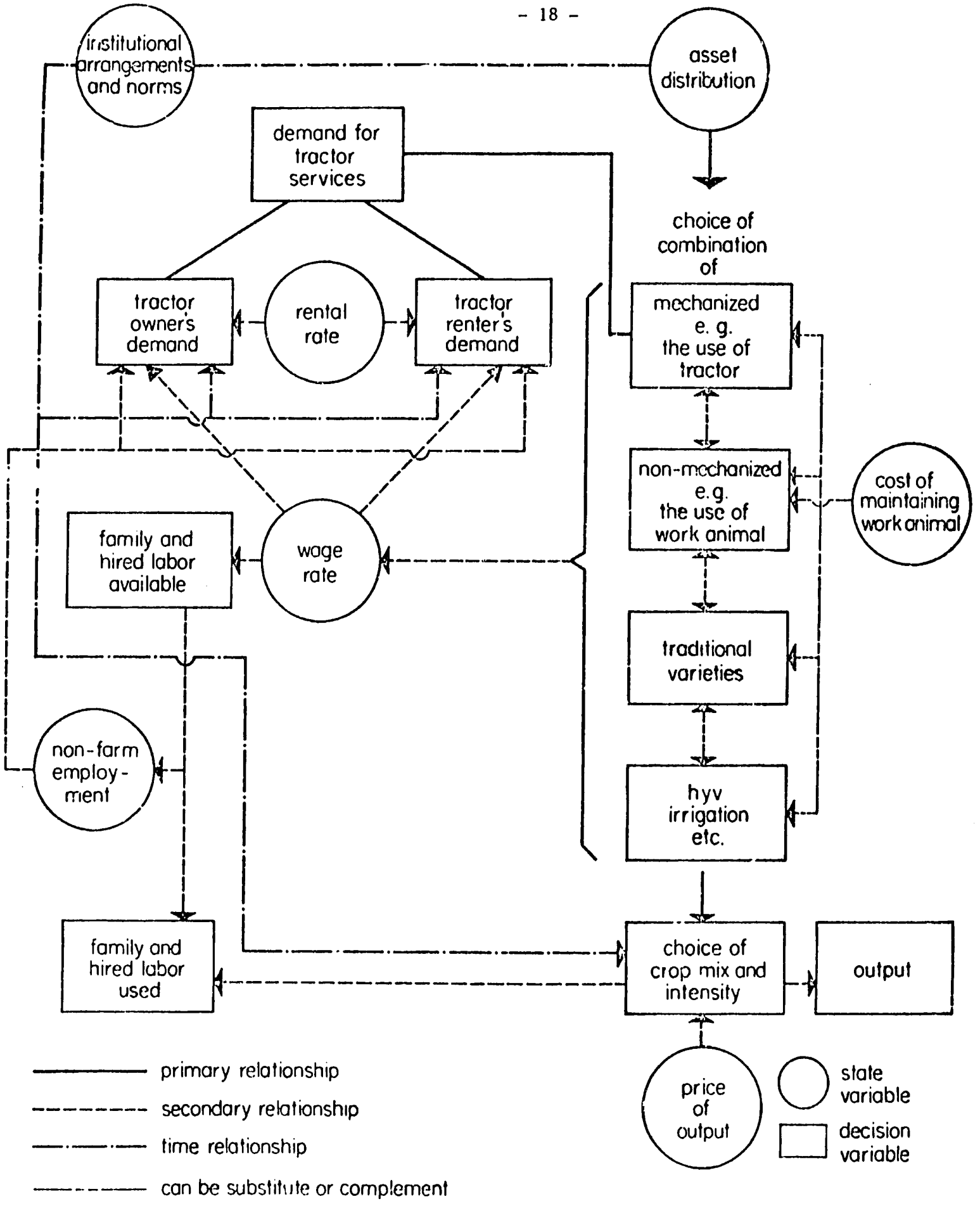

Fig 2. Diagram showing the factors affecting demand for tractor services at farm level

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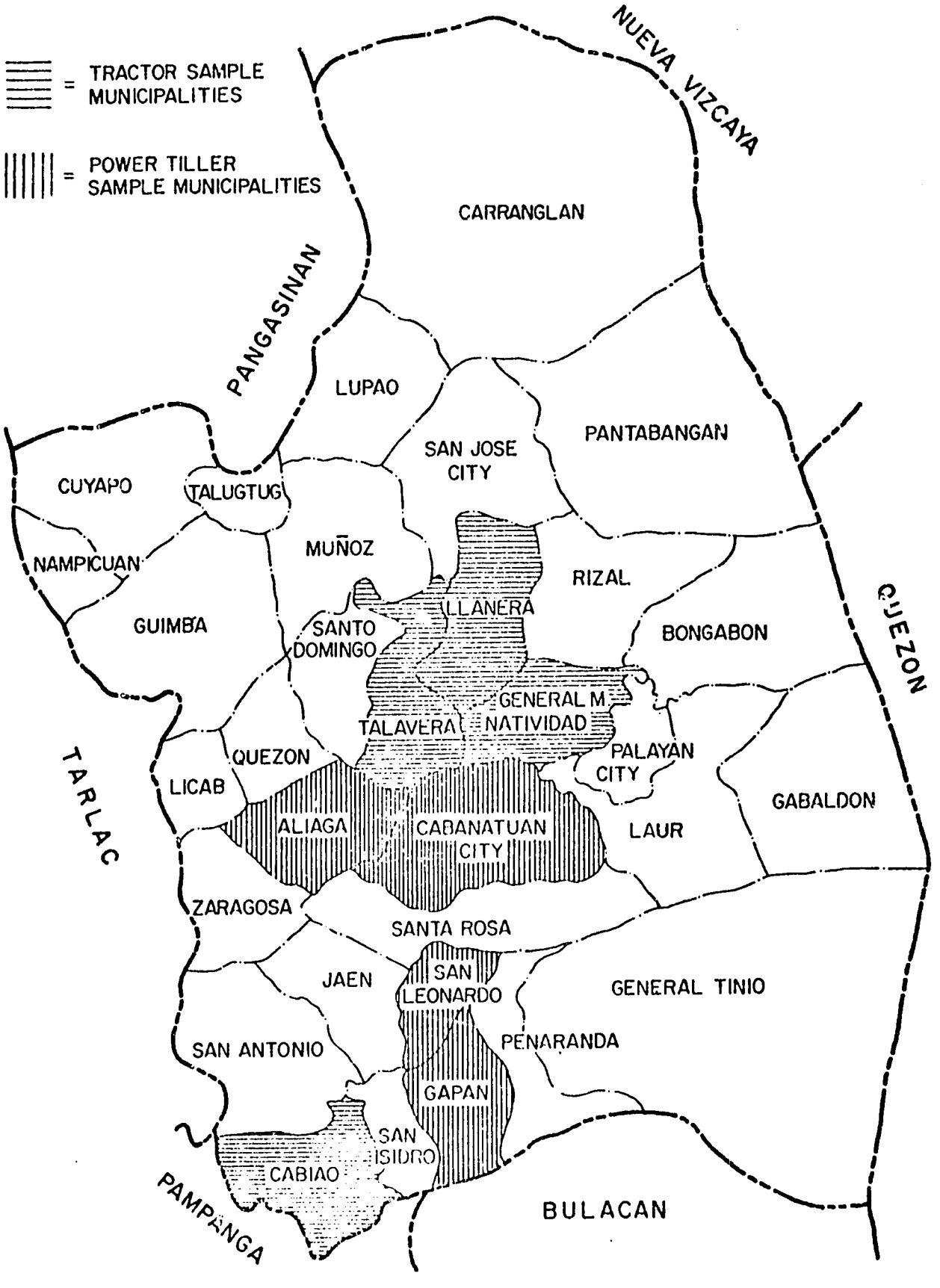

Fig. 3. Map of Nueva Ecija province showing the sample municipalities.

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