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REGIONAL TOTAL FACTOR PRODUCTIVITY CHANGE IN PHILIPPINE AGRICULTURE

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The application of total factor productivity accounting methods to Philippine agriculture is not new. Hooley analyzed prewar productivity growth. Lawas (1965), Paris (1971), David and Barker (1979), and David, Barker and Palacpac (1985) have analyzed postwar data for aggregate Philippine agricultural data. Only one previous attempt to develop a regional analysis has been made by Antonio, Evenson and Sardido (1977). This paper reports on an updated and more comprehensive analysis of regional total factor productivity change in Philippine agriculture.

The concept of total factor productivity measurement has been subject to some controversy in recent years (Nelson 1985; Denison 1962; and Jorgenson and Griliches 1967). However, most of the older methodological problems have been largely resolved and we discuss the foundations of our methodology in Part I in order to clarify these issues and show the basis for our calculations. In Part II we discuss the rationale for regional measures. Part III discusses data and measurement problems specific to Philippine agriculture. Part IV reports partial and total factor productivity measures for nine Philippine Economic Regions for the 1949-74 period and for 12 Philippine Economic Regions for the 1975-84 period. As we note in our methodological section, we do not view these productivity measures as being associated with particular sources of productivity growth. Indeed, we see them chiefly as a means to separating economic growth indexes into growth accounted for by conventional factor growth and total factor productivity growth. This separation then enables further analysis of growth factors.

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I. PRODUCTIVITY MEASUREMENT

Productivity measures are generally classified as "partial" or "total." The two partial indexes most widely used in agriculture are the ratio of crop output to land cultivated or yield and the ratio of crop or crop and livestock output to labor input, or labor productivity. These ratios have clear intuitive meanings, and we will report both partial measures in this paper. Our major attention will be directed to a measure of total factor productivity. The intuitive meaning of this measure is less obvious.

The total factor productivity measure that we will use can be derived in several alternative ways. The simplest and least restrictive is based on an accounting identity. The measure can also be derived as a "residual" from a production function, a minimized cost function, or a maximized profit function. (The overview paper discusses these alternatives.) In this paper, we will simply develop the "production function" version of the index. We begin with a production function that characterizes the relationship between output (Y, which may be an aggregate of several products) and inputs, $X_1 - X_n$, which include both variable and fixed inputs:

(1) $Y = Y\ (X_1, \ldots, X_n)$

It is important to note that several things are "held constant" in the background behind this expression. Specifically, the technology set available to farmers, the existing infrastructure (roads, markets) and transactions costs (legal system, etc.) are all treated as constant in (1). One of the purposes of productivity analysis is to *infer* from data only on Y and the X's the probable contributions to output that changes in these factors in the background contribute. (Productivity measures enable statistical estimates to provide a measure of their contribution.)

To proceed in the most general way we differentiate (1) totally:

(2) $dY = \sum_{i=1}^{n} F_i\ dX_i$

where $F_i = \partial P \ \ \partial Y/\partial X_i$

The first order condition for profit maximization are:

$F_i = P_i/P_y$

where P_i and P_y are prices of inputs and outputs
Substituting these in for the F_i and dividing by Y we obtain:

$$(3) \quad \frac{dY}{Y} = \sum_i \frac{P_i dX_i}{P_y Y}$$

Multipylying each term in the summation by X_i/X_i and making use of the property that $\Sigma P_i X_i = P_y Y$, we obtain the basic growth equation:

$$(4) \quad \frac{dY}{Y} \quad w = \sum_i C_i \frac{dX_i}{X_i}$$

where C_i is a cost share.

This expression holds for small changes when the "background variables" are constant. It relates growth in output to growth in factors or inputs. When this equation does not hold, the logic of this development tells us that the background variables have not remained constant. This is the basis for the definition of total productivity change DTFP as:

$$(5) \quad \text{DTFP} = dY/Y - \sum_i C_i \, dX_i \,/X_i \text{ or more generally}$$
$$= \sum_j S_j \, dY_j/Y - \sum_i C_i \, dX_i/X_i$$

This expression can be developed from much weaker assumptions (see the overview paper) but we believe the production function derivation to be appropriate to this paper. Notice that this development separates total output growth into two parts; one part due to measured input growth; the other due to changes in background variables (the DTFP growth). It does not identify the DTFP growth with any particular background variable. Furthermore, errors of measurement and random weather effects in (1) will be reflected in the DTFP measure.

We have used (5) as the basis for our DTFP growth measurement in this paper. Since (5) is exact only for small changes it is essential that we do not impose constant S_j and C_i shares over several periods of time because that would only be consistent with a Cobb-Dougles production specification (when prices are changing Cobb–Douglas shares remain constant). Accordingly, we compute (DTFP for each pair of years *(t, t*-1) using shares for the *t*–1 period. In the next period we update the shares. The actual formula is:

$$DTFP_{t,t-1} = \sum_j S_{j,\ t-1}\ [ln(Y_{j,t}) - ln\ (y\ Y\ (Y_{j,t-1})\ ] - \sum_i C_{i,\ t-1}\ [(ln\ (X_{i,t}) - ln\ (X_{i,t-1})\ ]$$

We define our labor productivity change index as:

$$DLABP_{t,t-1} = \sum_j S_{j,t-1}\ [ln\ (Y_j\ ) - ln\ Y_{j,t-1}\ )] - [(ln\ /(L_t) - (L_{t-1}\ )]$$

and the change in land productivity as:

$$DLANDP_{t,t-1} = \sum_j^{crops} S_{jt}\ '\ [\ ln\ (Y_{j,t}') - ln\ (Y'_{j,t-1}\ )] - [\ ln\ (A_t) - ln\ (A_{t-1})]$$

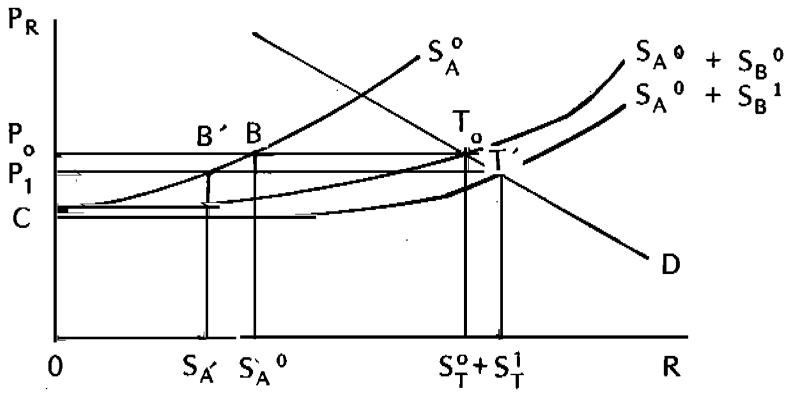
where the output variable includes only crop outputs. (Note that the logarithmic difference is reversible. Thus, a weather shock followed by a recovery period will not affect the level of the index in later periods.)

II. REGIONAL PRODUCTIVITY ISSUES

We are interested in regional productivity estimates for two reasons. The first is to provide data for further analysis of the relationship between output growth and change in the "background" variables. The second is that different rates of productivity growth by region can have serious income and labor market effects. Since we will not pursue the background variable analysis in this paper, the second issue is of most relevance.

Figure 1 illustrates the issue. In this figure, we depict a single national market for a commodity (e.g., rice). The commodity is produced in two regions: A and B. We have described the supply side of the market in two supply curves. S_A^O depicts the supply and production curve for region A. $S_A^o + S_B^o$ is the sum of S_A^o and S_B^o the supply curve in region B. The initial equilibrium is where total supply is equal to the national demand. The initial equilibrium price is P_o. Region A supplies S_A^O units. The payments to fixed factors in region A are the area P_o CB. Payments to variable factors (including labor) are $OCBS_A^o$. Comparable payments for region B are CBO and $OCT_o S_T^o - OCBS_A^o$

Figure 1



Now suppose that region B realizes productivity gains while region A does not. This shifts $S_B{}^o$ to $S_B{}^1$ (hence aggregate supply to $S_A{}^o + S_B{}^1$). Equilibrium output price will fall to P_1. Equilibrium output in region A will fall from $S_A{}^o$ to $S_A{}^1$. Payments to both variable and fixed factors in Region A will fall. It is thus clear that as long as there is some inelasticity of demand a region that does not realize the same productivity gains as realized elsewhere will be harmed. Both farmers and farm laborers will be harmed. Payments to fixed factors will include compensation for some family labor and farm management skills.

It is also clear from the figure that region B will increase its production. Even if demand were perfectly inelastic this would be the case. Of course, if demand were perfectly inelastic, payments to variable factors would not necessarily increase. Payments to fixed factors will not decline if the supply function shift is parallel. Labor can escape these regional impacts if it is mobile. It can move from A to B. Of course, if demand is sufficiently inelastic, net demand for labor will decline with productivity change.

This example illustrates the importance of first measuring productivity change, then analyzing its determinants at the regional level. Over a long period of time, regional productivity changes at different rates result in the emergence of backward and disadvantaged regions (such as A).

III. DATA AND MEASUREMENT PROBLEMS

The Appendix to this paper provides detail on the data used in this paper. We will only touch on the major issues here. First, we should note that we have two data sets instead of a single set because of changes in the definitions of regions. For the 1948 to 1974 period, we have organized the data on a 9-region basis. For the 1974 to 1984 period our data are for 12 regions. We report the changes in our indexes by 5- and 10-year periods, thus avoiding the problem of linking the series exactly. For some comparisons we have collapsed the 12-region data for the 1974-84 period into the nine original regions.

As the Appendix notes, some interpolation and extrapolation of series was required, particularly on the input side. For outputs, our data are quite complete both for prices and quantities. We have utilized BAEcon data for both crop and livestock output.

The input series are subject to the following qualifications:

1) Land

Annual crop area data include the effects of multiple cropping. In general, an increase in multiple cropping does not constitute an increase in land services – unless some investment in land irrigation or drainage made it possible. Normally it reflects an increase in other inputs. We have attempted to construct a land series purged of multiple cropping. For coconuts, fruits, and nuts, we treated the annual area harvested as being single cropped area. For annual crops, we used the arable land measure from the 1948, 1960, 1970 and 1980 censuses of agriculture. We also did this for land under permanent meadows and pastures. Irrigated rice area was considered to be a measure of irrigation services. For each type of land we constructed a rental series for the 1948-74 data. For the more recent period we assumed constant shares for each type of land. (The total share of land was fixed at .3.)

2) Labor

This series is based on annual data from the Philippine Statistical

Survey of Households. A number of adjustments were made for years prior to 1967. The general reliability of this series may be regarded to have improved after 1967. An equivalent man-days series was constructed. Wage data are from BAEcon surveys and refer to wages without meals.

3) Farm Machinery

This series is based heavily on annual national stock data for four-wheel tractors and hand tractors and plows, harrows and other implements. Data for regions for 1956 were used to distribute these machine stocks to regions.

4) Fertilizer

This series is similar to the farm machinery series in that a national consumption series can be constructed from a number of sources. Regional data for 1966 to 1969 were used to distribute fertilizer to regions.

5) Work Animals

This series is based on the 1948, 1960, 1971 and 1980 Censuses of agriculture. Working carabaos and cattle stocks were estimated for each region by interpolation between censuses. The service flow includes an adjustment for feed.

Appendix Table 1 shows factor shares for the nine regions for 1952, 1974 and 1983. These data show the factor share of animal power to have declined over time as has the share of labor. The shares of fertilizer, machines, irrigation and tree capital have increased significantly. The fertilizer share has risen very substantially over the 1970 to 1984 period.

IV. PRODUCTIVITY MEASURES

Table 1 provides a general overview of output and productivity change for Philippine agricuture. Crop productivity changes, labor productivity changes, and total factor productivity changes are summarized by 5-year and 10-year periods. These periods are not moving

TABLE 1

CHANGES IN OUTPUTS, INPUTS, CROP PRODUCTIVITY AND TOTAL FACTOR PRODUCTIVITY, PHILIPPINE AGRICULTURE 1950-84

	1950-1954-	1955-1959	1960-1964	1965-1969	1970-1974	1975-1979	1980-1984	1955-1964	1965-1974	1975-1984
Annual Changes										
Crop output	.067	.028	.032	.043	.037	.071	–.000	.030	.040	.035
Lvstk output	.076	.069	.005	–.031	.019	.042	.051	.037	–.006	.046
All output	.068	.032	.028	.034	.036	.062	.012	.030	.035	.037
labor inputs	.029	.019	.020	.015	.004	–.043	.051	.020	.009	.004
Land inputs	.009	.008	.008	.008	.007	.023	.012	.008	.007	.018
All inputs	.047	.007	.010	.026	.019	.009	.024	.009	.022	.017
Crop Productivity										
Rice	–.004	–.017	.009	.040	–.022	.051	.025	–.004	.009	.038
Corn	–.026	.026	.016	.039	.022	.042	.016	.021	.031	.029
Vegetables	–.064	.036	.114	.037	.054	.050	–.007	.075	.046	.021
Rootcrops	.041	.021	.027	–.014	.019	.122	–.027	0.24	.002	.022
Fruits	.017	.033	.084	.049	.119	.145	.032	.058	.85	.088
Sugar	–.007	.051	–.050	.040	–.011	–.007	.023	.000	.014	.008
Coconut	.063	–.022	–.020	–.008	–.020	.074	–.071	–.021	–.015	.001
Tobacco	–.000	.030	–.021	.031	–.013	.000	.052	.005	.009	.026
Other	.095	.028	.056	.024	.061	–	–	.042	.042	
Multiple cropping	.042	.028	.011	.014	.025	.001	–.012	.019	.019	–.006
All crops	.059	.020	.023	.035	.030	.048	–.013	.022	.032	.017
Labor Productivity	.039	.012	.008	.019	.032	015	–.038	.010	.026	.034
Total Factor Productivity										
Land rents based	.021	.024	.018	008	.014	.053	–.011	.021	.013	.021
Fixed share (.3)	0.27	.025	.019	.010	.021	053	–.011	.022	016	.021

averages and are thus not comparable to the calculations provided by David, Barker and Palacpec (1985). The same geneal pattern as shown by David, Barker and Palacpac emerges, however.

Output growth is relatively constant over the three ten-year periods, rising from 3 percent in the first decade to 3.7 percent in the 1975-84 decade. The five-year period data, however, show (as do David et al.) that output growth was highest in the early 1950s and late 1970s. Input growth, on the other hand, was highest in the 1950-54, 1965-70 and 1980-84 periods.

Total factor productivity growth accordingly was highest for the 1955-64 and 1975-84 periods at 2.1 percent annually, well above the productivity growth exhibited during the "green revolution" decade, 1965-74. Inspection of the 5-year period growth rates for total factor productivity shows that the post-green revolution period, 1975-79, exhibited very high productivity growth while the period of "economic crisis," 1980-84, showed negative productivity growth.

The pattern of productivity growth for the earlier periods was one of deterioration from over 2 percent in the 1950s to less than 1 percent in the late 1960s. The late green revolution period, 1970-74, showed an improvement to roughly 2 percent, leading to the exceptional productivity performance in the late 1970s.

Labor productivity data show a similar though accentuated pattern. The late 1970s show a very high rate of labor productivity growth.

Crop productivity or yield changes, in contrast, show a more even pattern. In fact, yield increases for all crops were actually highest in the 1965-74 decade even though total factor productivity growth was lowest during this decade than in the preceding and succeeding decade. Input data show that this decade was characterized by high input use. Thus, even though the conditions of this decade, notably the introduction of high-yielding rice varieties and other related technology led to crop yield increases, these gains were partially offset by increased input usage.

The crop productivity data are also interesting in that they show that rice is not the leading crop in terms of yield increases. Indeed, over the three decades it can be seen that fruits, vegetables and corn clearly outperformed rice, while root crops roughly matched yield increases in rice. Coconuts have shown no yield increases. Rice yields did increase rapidly in the early green revolution period, 1965-69, and in the post-green revolution period, 1975-79. They did not decline drastically in the economic crisis period.

Table 2 reports a regional summary for the nine original regions of output, crop productivity and total factor productivity growth for the three decades, 1955-64, 1965-74, and 1975-84, and for the overall 1950-84 period. Appendix Table 2 reports data for 5-year periods and the 12-region data for the last two 5-year periods.

Turning first to the overall total factor productivity performance we find one or two somewhat surprising results. The two leading regions over the entire period are clearly the Southern Tagalog and Northern-Eastern Mindanao regions with 2.4 to 2.5 percent productivity growth rates. The Ilocos and Eastern Visayan regions show overall growth rates in the 1.4 to 1.6 range. Western-Southern Mindanao productivity growth is a little over 1 percent and Western Visayan and the Cagayan Valley are a little below 1 percent. The Bicol and Central Luzon regions show no productivity growth.

Perhaps the most surprising computations are those showing poor performance of the Central Luzon region. The data show output growth and crop productivity growth for Central Luzon. The modest yield gains of the 1965-74 period were offset by increased input usage. As noted earlier, rice yields do not show high rates of change, and even in the 1975-79 period, Central Luzon shows only modest total factor productivity gains.

The outstanding performance of the Southern Tagalog region is consistent with the substantial investment in productivity-enhancing research, extension and infrastructure in the region. The Mindanao regions have apparently enjoyed some benefits from their frontier status, as well as from improved infrastructure and some improvements in maize technology. They have also benefited from the expansion of fruit production. The Western Visayan region did well in the early decades but the poor performance of the sugar sector led to a poor overall performance. The Eastern Visayan region, on the other hand, has benefited from increased research, extension and infrastructure investment. The Ilocos region also appears to have benefited from public investment.

V. CONCLUDING REMARKS

These calculations show marked differences in agricultural productivity performance by region. They also offer opportunities for further analysis. We have not attempted a thorough analysis of the sources of productivity change in this paper. We believe, however, that the calculations do have meaning in terms of measures of changing efficiency

TABLE 2
PRODUCTIVITY SUMMARY BY ORIGINAL NINE REGIONS

	Ilocos	Cagayan Valley	Central Luzon	Southern Tagalog	Bicol	Eastern Visayas	Western Visayas	Northern-Central Mindanao	Western-Southern Mindanao	Philippines
Output Growth										
1955-64	.015	.028	–.005	.002	.023	–.006	.014	.018	.063	.030
1965-74	.059	–.001	–.006	.021	.001	.030	.013	.084	–.037	.035
1975-84	.026	.010	.007	.026	020	020	.024	.033	.039	.034
1950-84	.024	023	.003	.024	.017	.022	.024	.049	.030	.039
Crop Productivity										
1955-64	.028	.038	–.005	.030	.013	.010	.016	.059	.097	.022
1965-74	.091	–.006	.018	.056	–.005	.051	.021	.115	–.021	.032
1975-84	.026	–.004	.013	.014	.020	.027	–.000	–.000	.024	.017
1950-84	.037	.020	.011	042	.012	.037	.020	.064	.043	.029
Total Factor Productivity										
1955-64	.015	.021	015	015	–.010	.008	.011	.012	.048	.021
1965-74	.063	–.008	–.011	.011	–.017	.029	.002	.040	–.067	.013
1975-84	.011	–.005	.005	.035	–.002	.016	.007	.015	.040	.021
1950-84	.0160	.0073	.0000	.0239	.0047	.0146	.0083	.0254	0109	.019

of agricultural production. They raise a number of questions and suggest further lines of inquiry.

They also suggest that significant regional effects on welfare of rural people may be associated with differential regional performance. The relatively poor performance of the Bicol region, for example, suggests that agricultural laborers and small farmers have probably not fared as well in that region as in other regions. Migration patterns, both rural-to-urban and rural-to-rural, have probably also been affected by regional productivity performance.

We hope that these initial calculations serve to stimulate further analysis of the economic issues associated with regional productivity performance.

APPENDIX

SOURCES AND METHODS USED IN CONSTRUCTING THE REGIONAL TIME SERIES DATA

Our regional time series data set on quantities and prices of agricultural inputs and outputs builds on the earlier works of Lawas (1965). Paris (1971), Crisostomo (1972), and Antonio, Evenson, and Sardido (1977). All estimates are reported according to the original 9-region classification of the Philippines since most of the data are available in this detail only. For the 1974-84 period estimates are reported for the new 12 regions in Appendix Table 2.

Agricultural Output

Agricultural output is defined as the gross value of production of agricultural crops and livestock. The main sources of data for this series are the Raw Materials Resources Survey for Agriculture (RMRSA) of the Department of Agriculture and Natural Resources (DANR) for years before 1954 and the Crop and Livestock Survey of the Bureau of Agricultural Economics (BAEcon), DANR, from 1954 onwards. In many instances, these data sources report the components of agricultural output on a crop year basis, i.e., from July 1 to June 30. Adjustments were made to express these output components on a calendar year basis by simply taking averages of two consecutive crop years.

a) *Crops*

Regional agricultural crop production includes palay, corn, coconut, sugarcane, fruits, and other crops production. Other crops production refers to the combined production of rootcrops, onions, potatoes, beans and peas, vegetables, coffee, cacao, peanuts, abaca, tobacco, cotton, kapok, ramie, rubber, maguey, and other commercial and food crops. Original estimates of sugarcane production had to be recomputed since these are reported by BAEcon as the sum of centrifugal sugar, muscovado, panocha, and molasses and thus include sugar processing costs. These costs were subtracted from the original production estimates by assuming that 35 percent of the value of processed sugar is the cost of processing. Although the BAEcon also includes processing costs in its estimates of coconut production (copra and desiccated coconut), no attempt was made to correct for this since these costs are generally small.

The RMRSA and the CLS report regional output quantities and values (at farm prices) by crop. Annual crop prices were computed as crop value over quantity of production.

b) *Livestock and poultry*

Our estimates of livestock and poultry production include meat, milk and egg production as well as changes in livestock and poultry inventories. These estimates cover only farm households and therefore exclude small-scale backyard livestock and poultry production of non-farm households as defined by BAEcon. Annual regional population estimates of carabaos, cattle, hogs, horses, goats, sheep, chicken, ducks, geese, and turkeys as obtained from the RMRSA and the CLS were used to estimate yearly changes in livestock and poultry inventories from 1948 to 1984.

Dressed weights of slaughtered livestock and poultry in each region were also obtained from the RMRSA and the CLS though only for years 1955 to 1974. Ratios of dressed weights of slaughtered animals to their corresponding January populations were used to estimate meat production for the missing years. More specifically, the average ratios for years 1955 to 1959, 1966 to 1970, and 1981 were used to estimate meat production for years 1948 to 1965, 1966 to 1975, and 1976 to 1984, respectively.

Prices of livestock and poultry were computed in the same manner as crop prices. Meat prices were computed as the price of a particular animal divided by the average dressed weight of similar slaughtered animals. These dressed weight equivalents were obtained from the DANR.

Egg production includes only chicken and duck egg production. Data for years 1957 to 1980 are from the BAEcon. For other years, production of chicken egg and duck egg was estimated by first computing regional proportions of laying chickens and ducks to their respective populations for years 1948, 1960, 1971 and 1980 from the Censuses of Agriculture of the Bureau of the Census and Statistics (BCS) and subsequently interpolating to complete these proportions for years 1949 to 1956. It was assumed that laying chickens and ducks

Regional prices of chicken and duck eggs are taken from Prices Received by Farmers, a yearly BAEcon release, for years 1957 to 1984. Chicken egg prices in this study refer to the average prices of native and white leghorn chicken eggs.

Milk production includes carabao and cow milk production only. These were estimated by again taking the regional proportions of milking carabaos and milking cows to their respective populations from the 1948, 1960, 1971, and 1980 BCS Censuses and completing these series of proportions by interpolation and extrapolations. These proportions were subsequently applied to the carabao and cattle regional populations to obtain estimates of milking carabaos and cows for all years and for all regions. Milk production estimates were derived by assuming that a milking carabao or cow produces an average 197 liters of milk per lactating year.

Milk prices are the declared government milk prices pursuant to General Provision No. 41 and laid down under Animal Husbandry Administrative Orders 2-2 and 2-6. These orders provide the regulations governingg the disposal of animals, poultry, milk, eggs and milk products owned by the Bureau of Animal Industry. Milk prices in this study are assumed to be the same across all regions though not necessarily across all years.

Agricultural Inputs

a) Land

As a factor input in agricultural production, land may be argued to include land planted to temporary crops, land temporarily fallow/ idle, land under temporary pastures, land planted to permanent crops, land under permanent pastures, and land occupied by farm buildings, roads, and so on. In this study, agricultural land is classified to be either of two types only, i.e., (a) land planted to temporary and permanent crops or cultivated land, and (b) all other agricultural land.

In the RMRSA and the CLS, cultivated land is reported as crop area and so includes the effects of multiple cropping. In order to get the physical land area, multiple cropping indices, i.e., the ratio of crop area to physical area in each region, had to be computed from the 1948, 1960, 1971, and 1981 BCS Censuses of Agriculture. These multiple cropping indices were then completed for the missing years by interpolation and extrapolation. Reported crop areas planted were subsequently adjusted for land intensity use by dividing these estimates by their corresponding multiple cropping indices.

Area measures of other agricultural land (land under temporary and permanent pastures, land temporarily idle/fallow, etc.) are not available from the RMRSA and the CLS. This series had to be constructed by initially taking regional estimates of all other agricultural land from the 1948, 1960, 1971, and 1980 Censuses of Agriculture and again interpolating and extrapolating to complete the missing years.

b) *Labor*

Labor in this study is measured in equivalent man-days spent in agricultural production. The main source of data for this input series are the October rounds of the Philippine Statistical Survey of Households (PSSH) of the BCS. The PSSH surveys started in 1956 and have been undertaken annually since then. Unfortunately, the PSSH reports employment in agriculture, forestry, hunting and fishing as a group. Thus, labor employment in agriculture was taken to be a constant proportion (92 percent) of the reported total employment for this group of economic activities. Paris (1971) reports that agricultural employment comprised approximately 92 percent of total employment in agriculture, forestry, fishing and hunting for the intermittent years for which more detailed breakdowns of employment by industry group are available.

Regional data on employment in agriculture are available annually from the PSSH starting in 1967, with the exception of years 1969 and 1970 when no October labor force surveys were conducted. For 1969, the regional growth rates of agricultural employment from May 1968 to May 1969 were used to estimate the regional distribution of employment. The averages of the 1969 and the 1971 regional employment estimates were computed as the 1970 estimates

Regional employment breakdowns by sex and by age, i.e., 10-14 and 15 and over, are available for 1969 only. In order to obtain similar breakdowns for the period 1968-84, the national percentage distribution of agricultural employment by age for each of these years was applied uniformly to the regions. The within-region distributions of employment by sex, which are available for all regions (1968 to 1984), were then used to estimate the distribution of employment by sex for each age group in each region. Final agricultural employment estimates in each region therefore show year-to-year employments by age and by sex.

The regional distributions of total agricultural employment for the period 1956-63 are based on the percentage distributions of the agricultural labor force by region for these years. These distributions are from unpublished PSSH tables and are documented in Fonollera (1966). No PSSH survey is available for October 1964; thus, estimates of agricultural employment for this year were computed by applying the growth rate of employment from May 1963 to May 1964 on the October 1963 employment estimates. The regional distributions of total agricultural employment for years 1964 to 1966 were solved by initially computing for the regional percentage shares in total employment for 1963 and 1967 and subsequently interpolating for the same proportions for the in-between years. These proportions were then multiplied by their corresponding national employment figures to obtain regional estimates of employment for 1964 to 1966.

Breakdowns of total (national) employment by age and by sex are unfortunately not available for years 1956 to 1958. As such, these were estimated based on simple average percentage breakdowns computed from 1959 to 1963. Final 1956 to 1966 estimates of regional employment by age and by sex were arrived at by applying the 1956 to 1966 distributions of total employment by age and by sex to the regions.

Total agricultural employment for years 1948 to 1955 were projected using simple linear regression. To obtain regional employment estimates for 1948, the 1948 national agricultural employment estimates was broken down using the percentage distribution of employment from the 1948 Census of Agriculture. The procedure used to obtain the regional distributions of employment for years 1949 to 1955 followed that used to arrive at similar estimates for years 1964 to 1966. Finally, the age-sex breakdown of employment in each region was obained by first computing the 1948 proportions of employed by age and by sex from the 1948 Census and later interpolating for these proportions for the in-between years 1949 to 1955. These 1949 to

1955 national distributions of employed by age and by sex were subsequently applied to the regions.

Equivalent man-days *(LMD)* spent in agriculture per year were computed using the equation:

$$LMD_t = 23 \frac{m_t}{8} Ma_t + 15 \frac{f_t}{8} (.75)\ Fa_t + \frac{C_t}{8} (.50)\ (Mc_t + Fc_t)$$

where M = number of male workers,
F = number of female workers,
a = adult, i.e., 15 + years old,
c = children, i.e., 14 - years old,
m = average number of hours worked per week by male adults,
f = average number of hours worked per week by female adults,
c = average number of hours worked per week by children,
t = time

This equation was based on the judgment that females and children have working capacities equal to .75 and .50 respectively of working adult males. Also, the equation assumes that adult male workers work 23 weeks a year while female adults and children work only 15 weeks a year. These estimates are based on the study by Oppenfeld et al. (1957) where it is reported that an adult male farmer normally works 5.3 months a year while other family members work only 3.6 months in the farm.

Regional agricultural wages are from Balagot and Librero (1975) and BAEcon reports and refer to the average wage rates without meal per man-day in agriculture.

c) *Farm machinery and implements*

Farm machinery and implements refer to all durable agricultural equipment such as tractors, plows, harrows, threshers, and so on. The main sources of data used to construct this input series are (a) the 1948 Census of Agriculture, (b) the 1956 Capital Formation Study of the BAEcon, and (c) the annual estimates of gross domestic capital formation in durable agricultural machinery and implements from the National Economic and Development Authority's (NEDA, formerly the National Economic Council, NEC) National Income Accounts.

The series was constructed by taking the regional stock values of farm equipment in 1948 and 1956 from the 1948 Census and the 1956 Capital Formation Study, respectively, and initially filling in the missing years using simple linear interpolation. The national totals for 1948 and 1956 were then used as benchmarks. To estimate annual national stocks of farm equipment, the gross domestic capital formation data from NEDA were used in the equation

$$K_t = (1 - d) K_t = 1 + I_t$$

where K refers to the stock of farm equipment, I to gross domestic capital formation, d to the annual rate of depreciation and t to the time subscript. The annual depreciation rate was solved for using the 1948 and the 1956 benchmarks and the annual gross domestic capital formation data. The earlier estimated regional stock values of agricultural equipment for 1949 to 1955 were then correspondingly adjusted using simple proportions to sum to the national totals computed from the above equation. For years 1957 to 1975, the national estimate of the stock value of agricultural equipment was computed by again using the above equation. Regional estimates for these years were derived by assuming that the annual regional growth rates in the stock of farm machinery from 1956 follow those of the national.

The amount of capital services in each region was taken to be 16.2 percent of the total value of each region's agricultural capital stock – 10 percent assumed as the rate of interest and 6.2 percent as the depreciation rate.

Implicit price indices for farm equipment are computed from the National Income Accounts. They are assumed to be equal across regions in any particular year.

d) *Fertilizer*

The fertilizer input series was constructed from an amalgam of data sources. Our main data sources, however, were Anden (1976) and Paje, Kunkel, and Alcasid (1974), who both report tables on available supply and consumption of fertilizer as put together from data obtained from various sources such as the Fertilizer Institute of the Philippines, the Central Bank of the Philippines, the BAEcon, the Market Research Department of the San Miguel Corporation, the Marcelo Steel Corporation, and so on.

Total supply of fertilizer in nutrient equivalents, i.e., the sum of domestic production and imports unadjusted for year-end stocks, is given in Anden (1976) for years 1956 to 1975. This series was extended backwards to 1948 by converting total supply of fertilizer (unadjusted for year end stocks) available for years 1948 to 1955 into their nutrient equivalents. This was done using a constant conversion factor, i.e., the average ratio of total nutrient supply to total fertilizer supply for years 1956 to 1960.

Fertilizer nutrient equivalent consumption for years 1967 to 1975 are available in Anden (1976) for years 1967 to 1975. This series was completed assuming that (a) there was no carryover inventory of fertilizer from 1947 to 1948, (b) fertilizer nutrient equivalent consumption is a constant fraction of total nutrient supply for years 1948-1956, and (c) the total consumption of nutrients from 1948 to 1966 amounted to the same percentage of total supply (87 percent) as that from 1967 to 1975.

Fertilizer consumption for 1974-84 was based on fertilizer sales of distributor obtained from FPA. Regional series construction was done as follows:

1. For years 1974 to 1977 and 1981 to 1983, data on total sales of fertilizer were computed based on the proportion and the growth rate derived from the available data including 1978, 1979 and 1980.

2. The regional distribution of the total sales was also computed based on the proportion of fertilizer distributors by region and then multiplied by the total sales. Since only the years 1977 and 1984 had data on the total fertilizer distributors by regions, the 1977 data on regional distributors were applied to the years 1974 to 1979. For 1980 to 1983, the regional proportion used was that for the actual 1984 data.

3. Regional sales of fertilizer by nutrient were computed based on the proportion of *N, P,* and *K* to the total nutrient demand, then multiplied by the total sales by region.

Appendix Table 1 reports factor shares by region for the years 1950, 1975 and 1984. These data are reported for the original nine regions. The data for 1984 have been converted from the 12 regions' base to the original nine regions by assigning the three Visayan regions and the four Mindanao regions to the original two Visayan and two

Appendix Table 1
FACTOR SHARES: BY REGION

	Ilocos	Cagayan Valley	Central Luzon	Southern Tagalog	Bicol	Eastern Visayas	Western Visayas	Northern-Central Mindanao	Western-Southern Mindanao	Philippines
Animal Power										
1950	.209	.302	.299	.142	.159	.216	.197	.145	.190	.216
1975	.138	.200	.259	.163	.132	.261	.173	.101	.320	.167
1984	.168	.213	.116	.112	.126	.127	.115	.120		.123
Fertilizer										
1950	.007	.003	.007	.015	.002	.002	.011	.003	.003	.007
1975	.030	.006	.029	.045	.003	.007	.032	.005	.005	.018
1984	.122	.153	.162	.084	.085	.0124	.049	.0127	.086	.116
Labor										
1950	.605	.500	.439	.485	.643	.592	.588	.232	.497	.582
1975	.450	.275	.278	.318	.353	.447	.389	.570	.265	.306
1984	.383	.304	.284	.390	.459	.387	.478	.310	.372	.361
Machines										
1950	.012	.016	.023	.009	.011	.012	.040	.012	.042	.024
1975	.052	.037	.086	.044	.028	.053	.079	.021	.070	.047
1984	.032	.037	.078	.057	.020	.061	.0234	.082	.054	.054
Irrigation										
1950	.021	.010	.028	.002	.003	.003	.003	.001	.001	.008
1975	.112	.151	.078	.087	.092	.027	.055	.058		.017
1984	.026	.036	.077	.015	.012	.015	.014	.003	.023	.024
Tree Capital										
1950	.003	.001	.004	.017	.013	.010	.006	.009	.005	.009
1975	.008	.003	.004	.050	.035	.039	.013	.075	.039	.016
1984	.016	.007	.010	.019	.062	.048	.013	.103	.113	.069

Appendix Table 2
TOTAL FACTOR AND CROP PRODUCTIVITY GROWTH RATES BY REGION, PHILIPPINE AGRICULTURE

Region		1950-54	1955-59	1960-64	1965-69	1970-74	1975-79	1980-84
1 Ilocos	0	–.025	.060	–.029	.060	.058	.038	.015
	CP	–.032	.066	–.010	.116	.065	.039	.013
	TFP	–.067	.053	–.022	.074	.052	.041	–.019
2 Cagayan	0	.082	–.017	–.002	–.016	.013	.035	–.014
Valley	CP	.088	.063	.014	–.013	.000	.025	–.038
	TFP	.035	.068	–.027	–.028	.011	.036	–.047
3 Central	0	.031	.026	–.036	.026	–.039	.006	.007
Luzon	CP	.025	.021	–.030	.062	–.025	.021	.006
	TFP	–.021	.025	.005	–.004	–.017	.013	–.003
4 Southern	0	.072	.013	–.009	–.011	.059	.060	–.009
Tagalog	CP	.097	.039	.021	.043	.069	.071	–.043
	TFP	.045	.011	.019	–.007	.030	.086	–.016
5 Bicol	0	.033	.007	.039	–.024	.027	.063	–.024
	CP	.028	–.011	.038	–.023	.022	.079	–.040
	TFP	–.015	–.000	.021	–.054	.019	.050	–.054
6 Western	0	.067	.027	.001	.037	–.011	.031	.015
Visayan	CP	.068	.026	.006	.053	–.010	.018	–.027
	TFP	.018	.034	–.013	.016	–.017	.018	–.024
7 Central	0						.076	–.023
Visayan	CP						.084	–.066
	TFP						.101	–.048
8 Eastern	0	.068	–.010	–.002	.012	.047	.033	.001
Visayan	CP	.083	–.003	.023	.052	.049	.051	.020
	TFP	.028	–.023	.007	.012	.045	.031	–.011
9 Western	0	.077	.020	.106	.039	–.114	.072	.003
Mindanao	CP	.100	.044	.151	.085	–.127	.086	–.021
	TFP	.034	.024	.072	.004	–.139	.035	–.019
10 Northern	0	.074	.034	.002	.015	.152	.028	.028
Mindanao	CP	.103	.061	.057	.072	.159	–.003	–.006
	TFP	.044	.030	–.006	–.019	.100	.038	–.007
11 Southern	0						.039	.038
Mindanao	CP						.037	.006
	TFP						–.008	–.003
12 Central	0						.082	.000
Mindanao	CP						.006	–.048
	TFP						.059	–.015

Mindanao regions on the basis of province value of agricultural outputs.

Appendix Table 2 reports output growth rates, crop productivity growth rates and total factor productivity growth rates for 1975-79 and 1980-84 for the 12 new regions. For earlier periods, these calculations are made for the original nine regions.

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