THE CONTRIBUTION OF AGRICULTURE TO ECONOMIC GROWTH —
SOME EMPIRICAL EVIDENCE

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SUMMARY

This paper undertakes a statistical analysis of the significance of the contribution of agriculture to economic growth by the use of cross-section data. The major finding of the paper is that agricultural growth, while strongly linked to industrial growth over the development process, contributes to overall economic growth through its favorable impact on total factor productivity. In fostering productivity, the role of agriculture seems to be no less important than that of export performance. This empirical evidence reinforces the argument that agriculture and rural development should be given priority and be properly supported in an overall development strategy.
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I. INTRODUCTION

Despite the dominant position occupied by the agricultural sector in a traditional economy, many parts of the developing world have continuously denied agricultural and rural development adequate attention. This bias has often led to stagnant agriculture that, in turn, has resulted in large shortfalls in domestic food production, balance of payment crises, and political instability. For a primitive agrarian economy, it is doubtful that industrialization can succeed without the prior or concurrent emergence of a productive agricultural sector.

This paper undertakes a statistical analysis of the significance of the contribution of agriculture to economic growth by the use of cross-section data. The major finding of the paper is that agricultural growth, while strongly linked to industrial growth over the development process, contributes to overall economic growth through its favorable impact on total factor productivity. In fostering productivity, the role of agriculture seems to be no less important than that of export performance. This empirical evidence reinforces the argument that agriculture and rural development should be given priority and be properly supported in an overall development strategy.

Section II of this paper analyzes the relationship between agriculture and industry during the development process. Section III examines the contribution of agriculture to economic growth in the framework of a production function. The summary and conclusions are given in the last section.
II. THE RELATIONSHIP BETWEEN AGRICULTURE AND INDUSTRIAL GROWTH

The transition from a traditional agrarian to an industrialized economy is a dynamic process that inevitably involves complex interactions among many economic as well as social factors. The role of agriculture in the transition varies from country to country, conditioned by factor endowment, institutional arrangements, cultural background, historical factors, policy choices, etc. Nevertheless, drawing from the experience of both developing and developed countries, one can identify several important roles that agriculture plays in the transition process [e.g., Johnston and Mellor (1961), Johnston and Kilby (1975)]: (1) agriculture generates markets for industrial products, especially light industrial ones that have ready markets in the agricultural sector; (2) provides food and agricultural raw materials for industrial processing; (3) builds adequate food supplies that are a crucial factor in sustaining price stability; (4) provides exports to earn foreign exchange; (5) supplies the non-agricultural sector with capital and labor; and (6) in the case of a market-oriented economy, eases the process of industrialization through the gradual accumulation of entrepreneurship and marketing capabilities in the agricultural sector. In sum, agriculture supports industrialization by providing a source of labor, capital and raw materials to other sectors and by generating demand for industrial products.

At the same time, the relationship between agriculture and industry is one of interdependence and complementarity. For example,
while providing inputs to industry, agriculture receives from it modern farm inputs, advanced technologies, and consumption goods to increase its productivity. The statistical significance of this relationship may be tested by the following non-linear model of the Chenery-Syrquin (1975) type, which relates the rate of industrial growth \( I \) to per capita income \( YN \) and the rate of agricultural growth \( A \):

\[
I = f [A, \ln YN, (\ln YN)^2] + u, \quad (1)
\]

where \( u \) is a randomly distributed error term.

The model is derived in the following way. First, assume that the rates of growth of industry and agriculture are both non-linear functions of per capita income variables:

\[
I = \alpha_I \ln YN + \beta_I (\ln YN)^2 + \epsilon_I \quad (2)
\]

and

\[
A = \alpha_A \ln YN + \beta_A (\ln YN)^2 + \epsilon_A \quad (3)
\]

where \( \epsilon_I \) and \( \epsilon_A \) are random errors.
These are simplified reduced form models for the determination of industrial and agricultural growth. The per capita income variables are used as summary measures of the stage of economic development, in addition to being measures of final demand. Chenery and Taylor (1968) have used similar models to study patterns of economic development. Alternatively, these regressions can be thought of as establishing "norms" for the rates of growth of industry and agriculture with reference to the stage of economic development, as measured by the level of per capita income. It is possible to test the hypothesis of whether countries with higher industrial growth in relation to "normal" industrial growth are also those with higher agricultural growth with reference to its norm. This test can be made by regressing the residuals in (2) on the residuals in (3).

$$\epsilon_I = \gamma \epsilon_A + u, \gamma > 0,$$  \hspace{1cm} (4)

where u is a randomly distributed error term.

Substituting (2) and (3) into (4) and rearranging the terms yields

$$\dot{I} = \gamma A + (\alpha_I - \gamma A) \ln YN - (\gamma \beta_A - \beta_I) (\ln YN)^2 + u.$$  \hspace{1cm} (5)
This equation is the explicit form of (1). It also implies that the disparity between industrial and agricultural growth, $I - A$, is a second order non-linear function of per capita income.

The estimation of (5) is conducted using two cross-country samples: one consists of 63 countries for the decade of the 1960s and the other has 87 countries for the decade of the 1970s. Both samples include developing as well as developed countries. The data sources are described in the Annex; the estimation results based upon the ordinary least square method (OLS) are contained in Table 1.

First, note that the regressions with the per capita income variables alone (equations 1 and 2) depict a parabolic curve, a result that indicates that at a relative low level of income, industrial growth will increase as per capita income increases and that when per capita income reaches a certain level, the rate of industrial growth will reach a maximum and then taper off. This outcome confirms the hypothesis as formulated in (2).

Equations (3) and (4) show that the growth rate of agriculture is a statistically significant variable in explaining industrial growth and that it has raised the $R^2$'s significantly for both samples, especially for 1970-79. Although the statistical significance of the per capita income variables were reduced, the results unambiguously confirm the hypothesis that countries with the above-the-norm performance in industry are also those associated with the above-the-norm performance in agriculture over the development process that is manifested through a
Table 1: ESTIMATED REGRESSION COEFFICIENTS FOR ANNUAL INDUSTRIAL GROWTH

<table>
<thead>
<tr>
<th>Equation</th>
<th>Period</th>
<th>lnYN</th>
<th>(lnYN)^2</th>
<th>A</th>
<th>Constant</th>
<th>R^2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1960-70</td>
<td>9.277*</td>
<td>-0.658*</td>
<td>-</td>
<td>-24.331*</td>
<td>0.12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.7)</td>
<td>(2.8)</td>
<td></td>
<td>(2.1)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1970-79</td>
<td>13.068**</td>
<td>-0.904**</td>
<td>-</td>
<td>-40.594**</td>
<td>0.13</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(3.4)</td>
<td>(3.4)</td>
<td></td>
<td>(3.1)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1960-70</td>
<td>6.548</td>
<td>-0.458</td>
<td>0.491*</td>
<td>-16.730</td>
<td>0.18</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1.8)</td>
<td>(1.8)</td>
<td>(2.1)</td>
<td>(2.1)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1970-79</td>
<td>9.477**</td>
<td>-0.649*</td>
<td>0.722**</td>
<td>-29.873*</td>
<td>0.28</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.6)</td>
<td>(2.6)</td>
<td>(4.1)</td>
<td>(2.4)</td>
<td></td>
</tr>
</tbody>
</table>

Note: The numbers under the respective coefficients in parentheses are t-statistics. The coefficients with a significance level above 5% are indicated by * and those above 1% by **.

The notations have the following meanings:

I = The average annual rate of growth of industry, comprised of mining, manufacturing, construction, and electricity, water, and gas.


A = The average annual rate of growth of agriculture.

continuous rise in per capita income. Based on the 1970-79 cross-section data of 87 countries, this association is illustrated in Table 2 for a spectrum of per capita income levels. As the table shows, the expected values of industrial and agricultural growth rates as well as
Table 2: DISPARITY BETWEEN THE RATES OF INDUSTRIAL AND AGRICULTURAL GROWTH: I - A

<table>
<thead>
<tr>
<th>Per Capita Income (1979 US Dollars)</th>
<th>Agriculture</th>
<th>Industry</th>
<th>Disparity between Agriculture &amp; Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>I</td>
<td>I - A</td>
</tr>
<tr>
<td>100</td>
<td>0.6</td>
<td>0.4</td>
<td>-0.2</td>
</tr>
<tr>
<td>200</td>
<td>1.6</td>
<td>3.3</td>
<td>1.7</td>
</tr>
<tr>
<td>250</td>
<td>1.8</td>
<td>4.0</td>
<td>2.2</td>
</tr>
<tr>
<td>500</td>
<td>2.4</td>
<td>5.7</td>
<td>3.3</td>
</tr>
<tr>
<td>1,000</td>
<td>2.7*</td>
<td>6.6</td>
<td>3.9</td>
</tr>
<tr>
<td>1,500</td>
<td>2.7</td>
<td>6.6*</td>
<td>4.0*</td>
</tr>
<tr>
<td>2,500</td>
<td>2.5</td>
<td>6.3</td>
<td>3.9</td>
</tr>
<tr>
<td>3,000</td>
<td>2.4</td>
<td>6.1</td>
<td>3.7</td>
</tr>
<tr>
<td>4,000</td>
<td>2.1</td>
<td>5.6</td>
<td>3.5</td>
</tr>
<tr>
<td>8,000</td>
<td>1.4</td>
<td>3.9</td>
<td>2.5</td>
</tr>
<tr>
<td>10,000</td>
<td>1.0</td>
<td>3.1</td>
<td>2.1</td>
</tr>
</tbody>
</table>

Note: * Indicates the peak value. The calculation is based on equation (4) in Table 1 for which the growth rates of agriculture at different per capita income levels are computed by the regression obtained for 1970-79: $-14.942 + 4.995 \lnYN - 0.354 (\lnYN)^2$; $R^2 = 0.06$. In this regression, the numbers underneath the respective coefficients in parentheses are t-statistics.
their disparities exhibit a quick rise over the low- and middle-income range (US$100 to US$1,500) but only slowly tapers off after the middle income range (US$1,500). While both agriculture and industry are accelerating their respective growth rates in the low-middle income range, the former reaches its peak growth rate at a per capita income level preceding the latter. This result seems to suggest that the development of agriculture precedes that of industry.

III. AGRICULTURE AND OVERALL ECONOMIC GROWTH -
A PRODUCTION FUNCTION APPROACH

The empirical evidence presented in the previous section suggests that a significant linkage exists between agriculture and industrial developments during the development process. In this section, I examine the contribution of agriculture to economic growth from the perspective of an aggregate production function. The hypothesis formulated and tested here is that agriculture contributes to economic growth through its impact on the rate of increase in total factor productivity; namely, agricultural growth shifts the aggregate production function upward.

There are at least two reasons why agricultural performance is closely related to the overall productivity of an economy. First, industrialization and the accompanying urbanization generate a growing need for food and raw materials that can only be met with adequate agricultural supplies. A poorly performing agricultural sector often
results in a terms of trade that is against industry, in a loss of foreign exchange, or in an inadequate demand for industrial output that restricts industrial expansion. These conditions hamper the transfer of resources from agriculture to industry or make it very costly. On the other hand, rapid agricultural growth makes feasible more per capita domestic consumption, higher exports of agricultural products, and greater absorption of the agricultural labor force by the industrial sector. Therefore, it enhances the resource transfer from agriculture to industry. As Robinson (1971) has shown, transfers of capital and labor from a lower productivity sector such as agriculture to a higher productivity sector as industry is by itself a distinctive source of economic growth.

Second, high agricultural growth largely reflects high average labor productivity in agriculture that, in turn, is supported by the high quality of human resources and physical capital inputs into the rural sector. For instance, comparing the variation in agricultural labor productivity between developing and developed countries, Hayami and Ruttan (1970) found that about two-thirds of it could be accounted for by the difference in technology, as embodied in fixed working capital and in human capital, broadly conceived to include the education, skills, and knowledge capacity present in a country's population. A more recent study of Kawagoe, Hayami, and Ruttan (1985) estimated that only a quarter of the productivity differences could be accounted by conventional inputs (land and livestock). These considerations argue for the inclusion of
the rate of agricultural growth as an additional variable in an aggregate production function to measure both the effect of the efficiency of resource transfers between agriculture and industry and of the impact of agricultural productivity on aggregate economic growth.

1. Other Variables Affecting Productivity Change

Other variables that could influence productivity changes should also be considered in order to minimize misspecification of the production function to be estimated below. Here, I consider two variables -- the rate of export growth and the rate of inflation. Other variables affecting changes in total factor productivity are summarized in the error term in the production function.

The contribution of exports to economic growth may be rationalized on such grounds as: (1) exports provide for economy-of-scale operations; and (2) exports enlarge the level of competition of domestic industries. These factors promote efficiency and therefore raise economic growth. A positive correlation between export growth rates and GNP growth rates for developing countries has been found in a number of studies, i.e., Michalopoulos and Jay (1973), Michaely (1977), and Krueger (1978). Recently, in the context of an aggregate production function, Balassa (1978), and Feder (1983) have all found that the growth in exports contributes significantly to inter-country differences in the rates of economic growth. These studies differed from earlier ones in that, besides exports, they simultaneously considered the contributions
made by factor inputs, i.e., capital and labor. They were, therefore, able to estimate the effects of exports on productivity growth.

The rate of inflation, in contrast, affects economic efficiency negatively for at least the following reasons (Tsiang, 1983). First, by increasing the variance of relative prices, inflation may make efficient planning of production difficult, and productivity suffers as a result. Second, inflation accompanied by government controls leads to very low real interest rates. This situation in turn leads to a false sense of the cheapness of capital and to its unproductive use. Below-equilibrium interest rates accompanied by high inflation could turn the flow of savings away from financial institutions and toward unproductive investments such as the hoarding of precious metals and investments in housing. Third, under the fixed exchange rate regime widely adopted by developing countries, inflation overvalues the domestic currency and leads to a loss in international competitiveness. The consequences are stagnant exports and balance-of-payment disequilibrium, conditions that often result in a more restrictive trade regime and loss of overall efficiency.

2. The Model

To test the hypothesis formulated above, I use the following Cobb-Douglas production function:

\[ Y = C K^\alpha L^\beta e^{\log R} \]  

(6)
where

\[
Y = \text{Gross domestic product}
\]

\[
C = \text{A scale parameter}
\]

\[
K = \text{Capital stock}
\]

\[
L = \text{The labor force and}
\]

\[
\text{elog } R = \text{The rate of technological change over time, which is taken to be synonymous with productivity change.}
\]

Rewriting the variables in (6) in terms of the rate of change over time yields

\[
\dot{Y} = a \dot{K} + \beta \dot{L} + \dot{R}.
\]

(7)

In the literature of production function analysis, the productivity change (\(R\)) in production function (7) is frequently treated as a "residual," and the production function is estimated accordingly. The argument presented here assumes that the rate of productivity change is positively influenced by both the rates of agricultural growth (\(A\)) and export growth (\(X\)), but is negatively related to the rate of inflation (\(P\)):

\[
\dot{R} = a + \gamma \dot{A} + \delta \dot{X} + \eta \dot{P} + \varepsilon, \quad \gamma, \delta > 0, \quad \eta < 0,
\]

(8)

where \(a\) is a constant term and \(\varepsilon\) is a residual, assumed to be randomly distributed. Combining (7) and (8) yields
\[ Y = \alpha Y + \beta K + \gamma L + \delta X + \eta P + \epsilon \]  

(9)

where

- \( Y \) = The average annual rate of growth of GDP
- \( K \) = The average annual rate of growth of capital, proxied by the average investment rate
- \( L \) = The average annual rate of growth of the labor force
- \( X \) = The average annual rate of growth of exports
- \( P \) = The average annual rate of inflation.

Before turning to the empirical estimates, several remarks are in order. First, although (9) includes the export and agricultural growth rates as regressors, it is essentially a production function and is not a national income accounting identity, since it does not have the appearance of a national income identity. Second, by including the inflation and agricultural growth rates as independent variables, the equation is an extension of the Balassa (1978) model, which includes only export growth as the shifting variable in a production function such as (6). Finally, the production function is assumed to be homogenous across countries.

The production hypothesis (9) is tested with cross-country samples from two periods — 1960-70 and 1970-79 by the ordinary least square method. For the first period, the sample includes 57 countries, of which 42 are developing. For the second period, because of the greater availability of country data, the sample is increased to 82
countries, of which 69 are developing. For both time periods, empirical results are obtained for both the developing country and the whole sample.

3. 1960-70 Period

First, with respect to the results from the developing country sample, note that the inter-country variations in capital and labor contribute to slightly less than one-third of the inter-country variations in total output (Table 3, equation 1). When the rate of export growth (X) and inflation (P) are added to the regression, the explained variations in total output rise from one-third to about one-half (equation 2) and labor elasticity falls significantly from 1.6 to 1.0. Export growth and labor force growth are significant at above the 5 percent level, but capital growth and inflation are not.

When the rate of agricultural growth is introduced as an additional shift variable in the production function, the explanatory power of the function is increased significantly (equation 3). The estimated elasticity of agricultural growth is about 0.6. However, the result also indicates the possibility of a strong collinear relationship between agricultural growth and labor force growth, since the coefficient of labor force growth is significantly reduced from 1.0 to 0.3, while the coefficients of all other variables are not significantly altered. The result could suggest that in developing countries, agriculture is very labor-intensive during the decade of 1960s, and the
### Table 3: ESTIMATED REGRESSION COEFFICIENTS FOR ANNUAL GROWTH IN GDP, 1960-70

<table>
<thead>
<tr>
<th>Equation</th>
<th>Country</th>
<th>K</th>
<th>L</th>
<th>X</th>
<th>P</th>
<th>A</th>
<th>Constant</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Developing</td>
<td>0.074</td>
<td>1.593**</td>
<td>0.608</td>
<td>0.32</td>
<td>0.608</td>
<td>0.32</td>
<td>0.32</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1.6)</td>
<td>(3.1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>0.065</td>
<td>1.030**</td>
<td>0.139**</td>
<td>-0.039</td>
<td>1.302</td>
<td>0.49</td>
<td>0.49</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1.6)</td>
<td>(2.8)</td>
<td>(3.4)</td>
<td>(1.4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>0.059</td>
<td>0.302</td>
<td>0.132**</td>
<td>-0.036</td>
<td>0.622**</td>
<td>0.896</td>
<td>0.66</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1.8)</td>
<td>(0.8)</td>
<td>(3.9)</td>
<td>(1.5)</td>
<td>(4.2)</td>
<td>(1.0)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>All</td>
<td>0.104**</td>
<td>1.162**</td>
<td>0.29</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.7)</td>
<td>(4.3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>0.072**</td>
<td>0.912**</td>
<td>0.158**</td>
<td>-0.040</td>
<td></td>
<td></td>
<td>0.51</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.2)</td>
<td>(3.9)</td>
<td>(4.7)</td>
<td>(1.7)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>0.076*</td>
<td>0.300</td>
<td>0.148**</td>
<td>-0.041</td>
<td>0.555**</td>
<td>0.782</td>
<td>0.66</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.7)</td>
<td>(1.3)</td>
<td>(5.1)</td>
<td>(2.0)</td>
<td>(4.7)</td>
<td>(1.0)</td>
<td></td>
</tr>
</tbody>
</table>

**Note:** This table is based on equation (9) in the text. The numbers underneath the respective coefficients in parentheses are $t$-statistics. The coefficients with a significance level above 5% are indicated by * and above 1% by a **.

Agricultural labor force constitutes a predominant part of the total labor force.

Because of the collinear relationship, the contribution of agricultural growth in the production function can be overestimated. I therefore perform an alternative test. This time I test whether the part of economic growth that cannot be explained by growth in factor
inputs (capital and labor) and in "other" factors influencing the productivity change (export growth and inflation) is significantly related to the rate of agricultural growth -- that is, I regress the unexplained residuals of the production function on agricultural growth as follows:

\[ Y - \hat{\alpha}K - \hat{\beta}L - \hat{\delta}X - \hat{\eta}P = \gamma A + \varepsilon, \]  

(10)

where \( \hat{\alpha}, \hat{\beta}, \hat{\delta}, \) and \( \hat{\eta} \) are the OLS estimates of \( \alpha, \beta, \delta, \) and \( \eta, \) respectively, when agricultural growth \( (A) \) is omitted from (9). This test is equivalent to that based upon (9) if all the regressors in (9) were orthogonal to each other, i.e., statistically independent. However, the test appears to be more robust because, unlike total economic growth itself, the residuals of the production function, as indicated by the left-hand side of (10), need not bear any systematic relationship with agricultural growth a priori.

The result of this test shows that the marginal contribution of agriculture to economic growth remains significant at the 1 percent level and that it accounts for an additional 18 percent of the increase in total factor productivity for developing countries (Table 4, equation 1). However, the estimated elasticity of 0.40 is significantly smaller than that estimated by the multiple regression (9).

The estimated coefficients obtained for the all-country sample that includes developed countries are very similar to those obtained for
Table 4: ESTIMATED REGRESSION COEFFICIENT FOR ANNUAL UNEXPLAINED GROWTH IN GDP

<table>
<thead>
<tr>
<th>Equation</th>
<th>Period</th>
<th>Country</th>
<th>A</th>
<th>Constant</th>
<th>R^2</th>
<th>No. of Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1960-1970</td>
<td>Developing</td>
<td>0.402**</td>
<td>-1.223</td>
<td>0.18</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(3.0)</td>
<td>(2.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>All</td>
<td></td>
<td>0.322**</td>
<td>-0.880</td>
<td>0.16</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(3.0)</td>
<td>(2.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1970-1979</td>
<td>Developing</td>
<td>0.348**</td>
<td>-0.693</td>
<td>0.20</td>
<td>69</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(4.1)</td>
<td>(2.2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>All</td>
<td></td>
<td>0.353**</td>
<td>-0.693</td>
<td>0.21</td>
<td>82</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(4.6)</td>
<td>(2.9)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: This table is based on equation (10) in the text. The numbers underneath the respective coefficients in parentheses are t-statistics. The coefficients with a significance level above 5% are indicated by * and above 1% by a **.

The developing country sample, but they are more efficient, as evidenced by the higher t-values (Table 3, equations 4-6). The elasticities of export growth are higher and of agricultural growth lower, an outcome suggesting that in high-income countries exports contribute more to economic growth, while agriculture less. Thus, agricultural growth accounted for an additional 16 percent of the increase in economic growth that is not explained by the variables already included in the model for the all-country sample, compared with the 18 percent obtained for the developing country sample (Table 4, equation 2).
4. **1970-79 Period**

The empirical estimates obtained for the period 1970-79 support the general patterns observed for the earlier period 1960-70 (Table 5). However, the estimates for this period are statistically much more efficient compared with the previous sample -- all the explanatory variables in alternative models are statistically significant either at 1 percent or 5 percent level. For instance, the inflation rate is found to be significant at above the 5 percent significance level, even though its negative impact on economic growth in absolute terms becomes smaller. The estimated coefficients of export growth are nearly twice as large as those obtained for the 1960-70 sample, a result indicating that the marginal contribution of exports to economic growth appears to be greater in the 1970s. The difference seems to lie in the behavior of developing countries, as, contrary to the 1960-70 results, the impact of exports on economic growth is greater for developing countries than for developed countries. (For instance, compare equations 3 and 6, Table 5.) There seems to be a shift in development strategy toward export-orientation in the developing world in this period. The contribution of agriculture to the increase in productivity is again found to be highly significant and accounts for 20 percent of the "unexplained" variations in economic growth (Table 4, equations 3 and 4), which is somewhat higher than the 16-18 percent estimated for the 1960-70 period. However, for the developing country sample, a 1 percent increase in agricultural growth is estimated to increase productivity by 0.35 percent during the
Table 5: ESTIMATED REGRESSION COEFFICIENTS FOR ANNUAL GROWTH IN GDP, 1970-1979

<table>
<thead>
<tr>
<th>Equations</th>
<th>Country</th>
<th>Independent Variables</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Constant</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>K</td>
<td>L</td>
<td>X</td>
<td>P</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Developing</td>
<td>0.178**</td>
<td>0.937*</td>
<td></td>
<td>-1.645</td>
<td>0.24</td>
<td></td>
<td>0.24</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(3.8)</td>
<td>(2.2)</td>
<td></td>
<td>(1.2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>0.097*</td>
<td>0.745*</td>
<td>0.281**</td>
<td>-0.022*</td>
<td>0.247</td>
<td>0.50</td>
<td>0.61</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.3)</td>
<td>(2.1)</td>
<td>(5.7)</td>
<td>(2.4)</td>
<td>(0.2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>0.098**</td>
<td>0.625*</td>
<td>0.235**</td>
<td>-0.022*</td>
<td>0.380**</td>
<td>-0.139</td>
<td>0.61</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.7)</td>
<td>(2.0)</td>
<td>(5.1)</td>
<td>(2.6)</td>
<td>(4.2)</td>
<td>(0.1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>All</td>
<td>0.174**</td>
<td>0.967**</td>
<td></td>
<td>-1.647</td>
<td>0.25</td>
<td></td>
<td>0.25</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(4.2)</td>
<td>(3.1)</td>
<td></td>
<td>(1.4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>0.094*</td>
<td>1.041**</td>
<td>0.263**</td>
<td>-0.019*</td>
<td>-0.554</td>
<td>0.49</td>
<td>0.49</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.5)</td>
<td>(3.9)</td>
<td>(5.8)</td>
<td>(2.1)</td>
<td>(0.5)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>0.096**</td>
<td>0.834**</td>
<td>0.219**</td>
<td>-0.020*</td>
<td>0.380**</td>
<td>-0.697</td>
<td>0.61</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.9)</td>
<td>(3.4)</td>
<td>(5.3)</td>
<td>(2.5)</td>
<td>(4.6)</td>
<td>(0.8)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: This table is based on equation (9) in the text. The numbers underneath the respective coefficients in parentheses are t-statistics. The coefficients with a significance level above 5% are indicated by * and above 1% by a **.

1970s, as compared with 0.40 percent during the 1960s. The decline in the role played by agriculture in economic growth is consistent with the increased degree of industrialization in developing countries.

However, the difference in regression results associated with the change in the sample period does not appear to be statistically significant, as the F tests, based on pooled regressions of both time
periods for both the developing country sample and all country sample
(Table 6), fail to reject the null hypothesis that the two samples in
either time period are homogenous. 5/

Table 6: POOLED REGRESSIONS

<table>
<thead>
<tr>
<th>Country</th>
<th>*</th>
<th>*</th>
<th>*</th>
<th>*</th>
<th>Constant</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developing</td>
<td>0.095**</td>
<td>0.835**</td>
<td>0.219**</td>
<td>-0.020**</td>
<td>-0.695</td>
<td>0.60</td>
</tr>
<tr>
<td></td>
<td>(2.9)</td>
<td>(3.5)</td>
<td>(5.4)</td>
<td>(2.5)</td>
<td>(4.7)</td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>0.096**</td>
<td>0.604**</td>
<td>0.188**</td>
<td>-0.021**</td>
<td>-0.094</td>
<td>0.61</td>
</tr>
<tr>
<td></td>
<td>(3.9)</td>
<td>(2.7)</td>
<td>(6.5)</td>
<td>(3.0)</td>
<td>(5.9)</td>
<td></td>
</tr>
</tbody>
</table>

Note: The numbers underneath the respective coefficients in parentheses are t-statistics. All
coefficients are significant above 1% level except constants.

The voluminous empirical literatures on production functions
(for both developed and developing countries) seem to indicate that the
Cobb-Douglas production function with constant-return-to scale provides a
very useful reference, if not always the true underlying function, for
studying the input-output relationship. In terms of the empirical
estimates of the developing country sample in Table 6, constant-return-to
scale implies a capital-output ratio of approximately 1.7. 6/ The
corresponding estimates for a selected number of countries and periods
are: China, 1.5 (1981); India, 2.5 (1978/79); Korea, 1.6 (1968); Japan,
3.5 (1965); and UK, 4.5 (1970) (China: Long Term Issues and Options,
Although international comparison of capital-output ratios is difficult because of the crudeness of capital stock estimates, our estimate does not seem to be unplausible for the developing countries. In other words, the estimated production function seems to be consistent with a Cobb-Douglas production function with constant return to scale. Furthermore, the empirical evidence seems to confirm the homogeneity assumption of the production function. 7/

In broad terms, the results based upon both periods validate the neoclassical production hypothesis formulated in (9). The inter-country differences in economic growth rates can be explained not only by the differences in factor endowments (capital and labor inputs) but more important, by the different performance of total factor productivity. The latter, in turn, is favorably affected by export and agriculture performances but negatively influenced by the inflation rate. 8/

5. Sources of Economic Growth Decomposition

The regression estimates for the 1970-79 period are more stable, efficient, and plausible than those for the earlier period. The estimated equation for the developing country sample for this period is then used for the "sources" of economic growth analysis discussed below.

Using the estimated regressions on economic growth, the average rate of economic growth during a period can be decomposed according to the "sources" of economic growth. For the developing countries sample of the 1970-79 period, during which the average rate of growth was 4.4
percent, the sources-of-growth decomposition indicates that capital and labor jointly contributed about 81 percent of the growth in total output, with the former contributing 48 percent and the latter 33 percent. The remaining 19 percent is explained by the productivity change, which in turn is determined by agricultural growth, export growth, and inflation (Table 7).

Table 7: SOURCES OF ECONOMIC GROWTH, 1970-79
(developing country sample)

<table>
<thead>
<tr>
<th>Factor Contribution</th>
<th>Average Growth Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Factor Contribution</td>
</tr>
<tr>
<td></td>
<td>Growth Rate (%) a/</td>
</tr>
<tr>
<td></td>
<td>Share (%)</td>
</tr>
<tr>
<td>Factors of Production:</td>
<td>3.5</td>
</tr>
<tr>
<td>of which:</td>
<td></td>
</tr>
<tr>
<td>Capital</td>
<td>2.1</td>
</tr>
<tr>
<td>Labor</td>
<td>1.4</td>
</tr>
<tr>
<td>Productivity Change:</td>
<td>0.9</td>
</tr>
<tr>
<td>of which:</td>
<td></td>
</tr>
<tr>
<td>Export</td>
<td>0.6</td>
</tr>
<tr>
<td>Inflation</td>
<td>-0.4</td>
</tr>
<tr>
<td>Agriculture</td>
<td>0.8</td>
</tr>
<tr>
<td>Other c/</td>
<td>-0.1</td>
</tr>
<tr>
<td>Total (GDP)</td>
<td>4.4</td>
</tr>
</tbody>
</table>

Note: Calculation is based on equation 3 in Table 5.

a/ The numbers in this column are obtained by multiplying the estimated elasticities by the average rates of growth of factors of production.

b/ Average investment rate.

c/ Reflecting the constant term.
It is worth noting that for the developing countries, the contribution of agricultural growth to productivity growth (0.8 percent) was greater than that of export growth (0.6 percent). Agriculture's contributing share in total productivity growth (17 percent) was thus also greater than that of export growth (14 percent). The inflation rate, on the other hand, reduced productivity growth by an average of 4 percent a year.

The historical growth-accounting analysis suggests that agriculture could be as dynamic as exports in generating economic growth in developing countries. Based on the orders of magnitude estimated, the role of agriculture seems to be no less important than that of exports in fostering productivity, and perhaps even more.

The policy implication seems to be that in formulating a development strategy, agricultural development ought to be given due attention. This strategy frequently means the adoption of appropriate exchange rate and pricing policies, adequate agricultural investments in infrastructure, research and extension facilities, and suitable training and health services for the agricultural labor force. Moreover, the shift in development strategy in favor of agriculture that brings out significant advances in productivity growth can often be carried out without additional physical investment. It involves institutional reforms such as those performed under land reform programs in several East Asian newly industrializing countries in their early stages of development. China's recent economic reform, which began with the
agricultural sector and subsequently brought about spectacular growth in agricultural output, also involved a fundamental reorganization of the basic mode of agricultural production.

IV. SUMMARY AND CONCLUSIONS

Using cross-section data of the 1960s and the 1970s, this paper has shown that the inter-country variation in industrial growth is significantly associated with the inter-country variation in agricultural growth over the development process. It has further demonstrated that agricultural growth induces productivity increases and, therefore, facilitates overall economic growth. Moreover, the paper estimated that the role of agriculture seems to be no less important than that of exports in fostering productivity. As argued in the paper, this result may stem from the fact that rapid agricultural growth raises the efficiency of resource transfers (capital and labor) between the agricultural and non-agricultural sectors, an improvement that results in an increase in overall productivity. Moreover, rapid agricultural growth itself may reflect high agricultural productivity. The paper also confirms earlier findings on the positive contribution of export growth to an increase in productivity. In addition, it shows that inflation has the opposite effect on productivity.

The implication of the main thrust of this paper for the long-term development strategy of low-income developing countries is clear: an appropriate agricultural development strategy should be formulated to
accelerate agricultural growth rates. While agriculture is inevitably a "declining industry" from the point of view of its share in total output over the long term, it should not be excessively squeezed for resources to support non-agricultural activities and therefore "abandoned" prematurely.

While cross-section analysis serves to uncover the common variables that determine the complex growth processes underlying individual countries and to summarize their "average" or "normal" experience and thus is a point of reference for analyzing individual country performance, it should be supplemented by detailed country studies to examine country-specific factors. Given the often unique conditions surrounding developing country agriculture, an examination of the contribution of agriculture to economic growth through the use of cross-section data, as was done in this paper, should clearly not be exempt from these remarks. In this context, it is worth noting that, based upon a general equilibrium analysis of the economy of the Republic of Korea, Adelman (1983) finds that its economic development could have fared even better under what she calls an "agricultural-demand-led industrialization program" than under a strategy based purely on export promotion.
NOTES

1/ For evidence, see World Bank (1981a).

2/ The explanatory power of these regressions are notoriously low, simply suggesting that per capita income variables alone are not sufficient to explain inter-country differentials in industrial growth rates. These results, however, should not be a source of alarm because our major purpose here is to establish the statistical association between industrial growth rates and per capita income levels, rather than to provide for a full model for ascertaining why industrial growth rates differ among countries. This argument also applies to the rest of the regressions reported in Table 1.

3/ Although the empirical evidence by itself does not necessarily imply that agricultural growth "causes" industrial growth in the Granger-Sims' sense (1969, 1972), we, nevertheless, have reasons to believe, as argued earlier, that agricultural growth does "push" industrial growth -- and it seems that this effect is what the empirical evidence reported above attempts to demonstrate. On the other hand, as also argued, industrial growth could also "pull" agricultural growth over the course of development and, to the extent that it is true, the estimates are subject to the classical simultaneous equation bias, the correction for which requires the specification of a complete model of agricultural and industrial growth that is beyond the scope of the present paper.
4/ Since \( K = \frac{Y}{K} \cdot \frac{I}{Y} \), the use of the investment rate to replace \( K \) assumes that the average capital-output ratio \( (K/Y) \) is a constant across countries.

5/ The test statistic is constructed as follows: 
\[
F(K_c, N - K_u) = \frac{(SSR_c - SSR_u)/K_c}{SSR_u/(N - K_u)}
\]
where \( SSR_c \) and \( SSR_u \) are, respectively, the constrained and unconstrained residual sum of squares; \( K_c \) and \( K_u \) are, respectively, the number of regressors in the constrained and unconstrained regressions; and \( N \) is the number of countries in the constrained regression. The constrained regressions are pooled regressions given in Table 6. The corresponding unconstrained regressions are given in Table 3 and Table 5.

6/ \[
1 - \frac{0.835}{0.095} = 1.7,
\]
since \( K \) is approximated by \( \frac{I}{Y} \), see note 4.

7/ The model could suffer from heteroskedasticity either because the production function is not homogenous across countries as assumed or because significant explanatory variables may have been omitted which contain distinctive variances. Whatever may be the cause, it is well known that in the presence of heteroskedasticity in the disturbances of an otherwise properly specified linear model leads to consistent but inefficient estimates and inconsistent co-variance matrix estimates. As a result, faulty inferences will be drawn when testing hypothesis in the presence of heteroskedasticity. To test whether heteroskedasticity is present in the regression model and to obtain consistent co-variance matrix in the presence of heteroskedasticity, I employ the White test (White, 1980). The test statistic \( nR^2 \) is
distributed as $\chi^2$ with $K (K + 1)/2$ degrees of freedom; where $n$, $K$ and $R^2$ are, respectively, the number of observations, the number of regressors and the squared multiple correlation coefficient from the regression of squared estimated residuals $\hat{\epsilon}^2_{in}$ on all second order product and cross-products of the original regressors $X_{ij}, X_{ik}$:

$$\hat{\epsilon}^2_{in} = \alpha_0 + \sum_{j=1}^{K} \sum_{K=j}^{K} \alpha_s X_{ij} X_{ik},$$

where $\alpha$'s are parameters to be estimated by OLS.

The test is performed for the regressions run for both samples. For the 1960-70 period, the test is applied to equations 3 and 6, Table 3 and for the 1970-79 period to equations 3 and 6, Table 5.

The test statistics corresponding to 21 degrees of freedom ($K = 5$) and five percent probability of type I error is 32.7. For the 1960-70 period, the computed test statistics are, respectively, 18.6 and 16.2 for the developing country sample and all country sample — both are smaller than 32.7 — the null hypothesis of no heteroskedasticity cannot be rejected. However, for the 1970-79 period, the test statistics are, respectively, 56.3 and 66.3 for the developing sample and all country sample. Hence the null hypothesis of no heteroskedasticity should be rejected. In this case, a consistent co-variance matrix of the disturbance term should be obtained to avoid faulty inferences. The method proposed by White does not
require any particular hypothesis regarding the co-variance structure for the purpose of obtaining consistent estimates. By employing the White estimator, the revised t values of regression parameters corresponding to the consistent standard errors for both samples are obtained. For the developing country sample, they show that export growth and inflation are significant at 1 percent significance level. Capital accumulation is significant at 5 percent level. However labor force growth and agricultural growth can only pass the 8 percent significant test. For the larger, all sample country sample, all variables pass the 1 percent significant test except agricultural growth, whose probability of type I error is 6 percent. The correction for heteroskedasticity thus weakens somewhat the statistical significance of agricultural growth. (I am indebted to Mr. Lant Pritchett of M.I.T. for the computer program that calculates the consistent co-variance matrix of the regression parameters.)

8/ Genberg and Swoboda (1986) also report that either the inflation rate or the variation of inflation is detrimental to economic growth.
Annex: DATA SOURCES

The data used in the paper are obtained mostly from the world development indicators annex of the World Development Report 1981 (World Bank, 1981b): 1979 GNP per capita in dollars (YN) and the average annual rate of inflation (P) are from Table 1 of the annex (pp. 134-35); the average annual growth rate of GDP (Y), agriculture (A), and industry (I) are from Table 2 (pp. 136-37); and the average annual growth rate of merchandise exports is from Table 8 (pp. 148-49). The Taiwan data, however, are obtained from corresponding tables in the World Development Report 1980 (World Bank, 1981c). The average investment rate (K) for the period and 1970 per capita GNP are obtained from the Economic and Social Data Division of the World Bank. The average annual growth rate of the labor force (L) is derived from the Social Indicators Data Sheets for individual countries compiled by the Economic and Social Data Division as of May 1982.
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