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ON THE AGRICULTURAL PERFORMANCE OF DEVELOPING NATIONS, 1950–85†

The purpose of this paper is to utilize the production estimates compiled by the U.S. Department of Agriculture's (USDA) Economic Research Service (ERS) to examine, cross-sectionally, the agricultural growth of developing economies in the post-World War II era.

The extensive coverage of the USDA data base[1] (including here 82 countries) and the long periods over which consistent estimates of output have been maintained permit examination of a number of propositions about the course of agricultural growth during development: most notably (1) the prediction—stemming from models of dualistic development—that an agricultural shortage phase may characterize the middle stages of development; and (2) the concept—embodied in the "Boserup effect"—that methods of agricultural production adjust over time to situations of increased population growth. In addition the data base supports an analysis of the structural characteristics of agricultural growth and an examination of the extent to which patterns of agricultural growth in relation to

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[1] The author is grateful to the USDA for providing data from its computerized series on production statistics by country and crop which underlies its *World Indices to Agricultural and Food Production* (USDA, various dates). Data used here were drawn from the USDA series as they stood in 1986, and prices used to aggregate crops are reported in USDA, 1986. Basic data by country covered are shown in Appendix Tables A.1–A.3.

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per capita income differ among countries in different geographic regions, a matter of some interest in light of the extensive discussion of the agricultural problems of Sub-Saharan African countries in the past decade and a half.

The discussion is set in terms of a rate of agricultural growth adequate to support economic growth which is derived from Johnston and Mellor's (1961) analyses of the role of agriculture in development. The implications of what this author shall call the "Johnston-Mellor adequacy," together with those implied by Boserup's (1965, 1981) analysis of the impact of population growth on agriculture, are considered and the problems of obtaining and interpreting cross-country data on agricultural performance are addressed. The basic results of the analysis are presented, while some observations on the interaction between data collection and interpretation of the record of agricultural performance are made in conclusion.

AGRICULTURAL PERFORMANCE AND DEVELOPMENT

Though the importance of agriculture to economic development was underestimated during the early years of development studies following World War II, by the 1960s the work of Kuznets and others had established the importance of structural transformation as a key process characterizing economic development (Kuznets, 1966; Chenery and Syrquin, 1973), and agricultural economists were quick to grasp that this transformation involved a number of critical interactions between agriculture and other sectors of the economy.

The notion of a shortage phase in agriculture imposing severe constraints on development processes was derived from Lewis' formulation of dualism (Lewis, 1954; Ranis and Fei, 1961[2]), and Johnston and Mellor provided perhaps the clearest statement of the role of agriculture in the "structural transformation model" of development of the 1960s. The evolution of the agricultural sector, they argued, was driven by "(1) an income elasticity of demand for food that is less than 1 and declining, and (2) the possibility of a substantial expansion of agricultural production with a constant or declining farm labor force" (Johnston and Mellor, 1961, p. 567).

A key aspect of Johnston and Mellor's analysis was the agricultural sector's role in meeting increased domestic demand for food. They noted that "failure to expand food supplies in pace with the growth of demand can seriously impede economic growth" (p. 571) through "a substantial

[2] Ranis and Fei made investment in agriculture critical to prevention of their shortage phase and uniquely defined balanced growth as involving an allocation of investment between industry and agriculture that maintained constant agricultural to industrial terms of trade (pp. 544–45).

rise in food prices leading to political discontent and pressure on wage rates with consequent adverse effects on industrial profits (and) investment" (p. 573). To this is added an implicit standard of agricultural performance: the growth of (domestic) food supplies to meet the growth of demand, given by

$$D^* = P^* + ey^*, \tag{1}$$

where

D^* = the predicted growth rate of (food) demand;

P^* = the growth rate of population;

e = the income elasticity of demand for food;

y^* = the growth of per capita income.

The income elasticity of demand for food is assumedly a declining function of levels of per capita income, though, as will be seen later, this function is more complex than suggested by Johnston and Mellor's initial discussion (pp. 572–73).

The structural transformation model of development implies a further interaction between agriculture and other sectors in the developing economy. If a smaller proportion of the labor force is to feed a growing population moving to other sectors of the economy, there is a necessary relationship between the growth of per worker agricultural productivity, the rate of change of agricultural labor as a share of the population, and the growth of per capita agricultural output. In fact,

$$a^* = \pi^* + \lambda^*, \text{i.e.,} \tag{2}$$

the growth of per capita agricultural output (a^*) is given by the growth of product per agricultural worker (π^*), and the rate of change in the agricultural labor force as a share of the population (λ^*), defined as

$$\lambda^* = L^* - P^*, \tag{3}$$

the difference between the growth rate of the agricultural labor force (L^*) and the growth rate of population (P^*). Expectedly negative, λ^* measures the transfer of labor resources from agricultural to other sectors of the economy characteristic as development proceeds.[3]

Structural transformation, while providing an overview of the interactions between agriculture and the economy as development proceeds, does not furnish a direct means of evaluating whether agricultural sector growth in a specific case has contributed to or retarded development, nor does it

[3] A negative λ^* does not necessarily imply that farmers are transferring to other sectors of the economy, but simply that new entrants to the labor force are being absorbed in the industrial and service sectors more rapidly than before.

provide a means of examining variations in agricultural performance among countries and the effects of these variations on development processes. Similarly, the concepts of self-sufficiency and food security do not seem very useful in providing a means identifying levels of agricultural performance adequate to avoid the onset of a shortage phase and the subsequent slowing of economic growth.

A simpler and considerably more useful approach to the measurement of agricultural performance during development can be derived from Johnston and Mellor's old formula for estimating the growth of demand for agricultural goods as development proceeds, embodied in Equation (1) above. Given appropriately measured components of agricultural output, and ignoring changes in stocks, a source-use decomposition of agricultural output can be set forth rather simply by:

$$A_t + M_t - X_t = C_t, \tag{4}$$

where

$$\begin{aligned} A_t &= \text{agricultural production;} \\ M_t &= \text{agricultural imports;} \\ X_t &= \text{agricultural exports;} \\ C_t &= \text{agricultural consumption in period } t. \end{aligned}$$

Letting $t = 0$ for some base reference period and defining net agricultural imports as $N_t = M_t - X_t$, we can define the initial position of a country in the base (reference) period by

$$A_0 + N_0 = C_0. \tag{5}$$

From this starting point a reference level of growth may be defined such that domestic production grows at the same rate as domestic demand is expected to grow by the Johnston-Mellor formula for predicting demand growth, i.e.,

$$A^* = D^*, \tag{6}$$

where $D^* = P^* + e_y y^*$ from Equation (1), or

$$D^* = D^*(P^*; e; y^*),$$

as per Mellor and Johnston (1984). This situation may be defined as Johnston-Mellor adequacy, and if preserved, should result ceteris paribus[4]

[4] The ceteris paribus covers the possibilities of changes in the industrial side of the equation, but—in terms of the Ranis-Fei formulation (1961)—implies no shortage phase arises in agriculture.

in the maintenance (a) of the (internal) agricultural: industrial terms of trade, and (b) of the same ratio of net imports (exports) to agricultural production, i.e.,

$$\phi_t = N_t/A_t = \phi_0 = N_0/A_0. \quad (7)$$

Alternatively, the failure of Johnston-Mellor adequacy implies either an increase in net agricultural imports as a share of agricultural production or an increase in the agricultural to industrial terms of trade, or both. A country whose agricultural performance exceeds Johnston-Mellor adequacy, i.e., where

$$A^* > D^*, \quad (8)$$

will end up with the option of reducing its net agricultural imports (or increasing its net exports) or allowing domestic relative agricultural prices to fall.

At the same time that a country exceeds, preserves, or fails to preserve Johnston-Mellor adequacy, it may increase or decrease its agricultural openness by raising the ratio of M/A and X/A. Mellor and Johnston (1984, p. 538) note a tendency to increased agricultural openness and food imports on the part of the countries with most rapid growth in staple food production; between 1961 and 1976 the 16 countries with the highest rates of growth of food staples more than doubled their food imports. Mellor and Johnston see this as part of a part of a pattern of development involving rough supply-demand balance at low income levels, followed by a period of rapid demand growth and food imports and, finally, increases in production catching up with domestic demand (pp. 539–40). The Mellor-Johnston perception corresponds to the prediction of a shortage phase by the Ranis-Fei model, though possibly for a different reason: an increase in the income-elasticity of demand, and thus D^*, rather than a failure of A^* to meet a D^* which remains roughly constant in the early stages of development.

The key parameter in the Johnston and Mellor formulation is e_y, the income-elasticity of demand for food. In their 1961 article Johnston and Mellor estimate this to be "on the order of magnitude of .6 or higher in low-income countries, vs. .2 – .3 in Western Europe, the United States, and Canada" (p. 572). Later analyses show the value to be higher at some levels of income, and focus on the expenditure elasticity of demand for cereals, which is a complex function of the expenditure elasticity of demand for cereals as food and for cereals as livestock feed. Using realistic elasticities from Asia, Mellor and Johnston (1984, p. 541) obtain a derived income elasticity of demand for grains ranging from .27 to .67.

The substitution of meat consumption for direct cereal consumption is assumedly behind the Mellor-Johnston patterns of supply-demand balance in agriculture, and the interaction of e_y with per capita income. Lluch, Powell, and Williams (1977, p. 54), summarizing time series analyses of their 17-country sample, find the average expenditure elasticities for food to be .60 for countries with 1970 per capita incomes between \$100 and \$500; .82 for incomes between \$500 and \$1,000; .67 for countries with incomes between \$1,000 and \$1,500; and .50 for countries with incomes above \$1,500. The Lluch, Powell, and Williams findings support the perception that a failure to maintain Johnston-Mellor adequacy may result from a rise in D^*, desired consumption, more than from a fall in A^*.

Although these findings give weight to the Mellor-Johnston hypothesis about phases of agricultural balance and shortage over the course of development, they offer very little information about the range of agricultural experience and the variations in consumption and production around the typical pattern associated with income. Johnston and Kilby's discussion of the low expenditure elasticity on food in Japan (1975, p. 215) indicates the range of variation in both production and consumption experience may in fact be quite wide. The links between levels of development (as proxied by per capita income) and agricultural demand and productivity provide promise of more refined measures of agricultural performance, and possible means of identifying the sources of an individual country's deviation from the typical evolution of agriculture with development.[5]

Another important element in assessing agricultural adequacy is the assumed nature of relationships between population growth and the growth of agricultural production. Initial discussions of the 1950s were fairly Malthusian in their formulation of the effects of rapid population growth: the increase in population growth from the early phase of the demographic transition was expected, in areas where there was no surplus land, to put considerable pressure on available food supplies.

In 1965 Ester Boserup published an influential book that challenged the neo-Malthusian approach to interpreting the effects of population growth. Amassing an immense body of historical and anthropological information,

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[5] If income elasticities and hence growth rates of agricultural demand are found to be related to levels of development, da^*, the deviation between adequate growth and that actually achieved by a country, can be decomposed to

$$da^* = d\hat{a}^* + d\pi^* + d\lambda^*,$$

where $d\pi^*$ is the deviation between country i's growth in per worker agricultural product and that predicted (as a development pattern) on the basis of its per capita income, $d\lambda^*$ is the similar deviation between country i's rate of change in the share of the population in the agricultural labor force and the pattern value, and $d\hat{a}^*$ is the difference between demand growth in the country and that predicted normally on the basis of its per capita income level and growth.

Boserup argued that population growth and concomitant increases in population density were the driving force of agricultural change; resulting in a progression of different cropping systems, agricultural technologies, forms of investment, and types of land rights.

Boserup's initial study did not make clear whether she felt the effects noted in historical context were at work in contemporary development experience, or how they might be observed in cross-country studies. Recent attempts to provide formal models of the effect vary over how it is seen to act (Simon, 1977; Darity, 1980; Pryor and Maurer, 1982; Robinson and Schutjer, 1984; Salehi-Isfehani, 1988) and the theoretical formulations of the effect do not suggest an unambiguous means of testing whether it operates in contemporary experience as revealed by cross-country analysis. Boserup does contrast the growth of per capita food production across countries, finding it greater in low-income countries with high rates of population growth than it is in the developed countries with lower rates of growth, but she does not standardize for the effects of development (i.e., per capita income) on demand for agricultural products (1981, chap. 16). Perhaps a minimum prediction of the Boserup hypotheses would be that, standardizing for levels of development, countries with higher rates of population growth would experience higher levels of growth of agricultural output.

THE DATA AVAILABLE ON CONTEMPORARY AGRICULTURAL PERFORMANCE

Any analysis of contemporary agricultural performance and economic development must rest on existing cross-sectional data. Here the observer of the contemporary (i.e., post-World War II) scene is at least in theory at a great advantage over his colleagues interested in agricultural growth in the eighteenth and nineteenth centuries. Since World War II a variety of systematic efforts have been made to provide a continuous record of data on agricultural inputs and outputs at a country level. The Food and Agriculture Organization (FAO) has assisted in the establishment of agricultural reporting services in individual countries and reports output by crop (from country-provided statistics) and an index of total agricultural production by country on an annual basis in the *Production Yearbook* (FAO, various years, b.). Similarly, agricultural trade data are collected from country sources and published annually in the FAO *Trade Yearbook* (FAO, various years, c.). Approximately every five years the FAO produces *Food Balance Sheets* (FAO, various years, a.) for each country on which it has sufficient data; these provide fixed points and benchmarks for the annual production series.

The FAO's data are supplemented by additional sources of records of agricultural output. The World Bank's efforts to construct roughly comparable tables of national accounts data involve estimation of value-added in agriculture by country and year derived from data underlying countries' national accounts efforts. In addition the USDA has for over 35 years constructed its own series of agricultural production indices for approximately 150 countries, drawing on country- and FAO-reported data, the reports of USDA agricultural attaches, and analysis of the USDA-ERS staff. USDA reports cover 15–50 major components of food and agricultural output for each country, and these are aggregated into overall indices of food and agricultural production using domestic price weights (converted into dollar values).[6]

The plentitude of data sources on the growth of Third World agriculture masks serious problems in collecting and interpreting the data, and discrepancies among the data reported by different agencies are significant. Even for specific crops, the USDA and FAO data sometimes diverge significantly—Paulino and Tseng (1980) estimated that in over 20 percent of the cases of cereal production figures the USDA and FAO estimates differed by more than 10 percent. The growth rates implied by the data aggregates reported by the FAO and USDA also differ, although the discrepancies have been reduced since the two agencies have attempted to coordinate some of their efforts ins response to budget crises they both have encountered since 1986. A recent survey of growth rates implied by the USDA/FAO series and the World Bank's series on value-added in agriculture in 13 African countries, however, shows a mean absolute deviation between the two sources equal to 50 percent of the growth rate for the 13-country average (Wells, 1988).

The discrepancies among data reported by different agencies reflect divergent means of obtaining data and problems in handling internal inconsistencies in reported data; but the basic problem is one of data collection itself. Agricultural censuses and sample surveys in developing countries, especially in Africa, are rare and historical data series frequently reflect impressionistic estimates turned in by district officers and other local officials.[7] Those involved in gathering the statistics will readily concede that what comes out of the process of continual monitoring of various direct

[6] After 1986, with severe budgetary constraints affecting both the USDA and FAO, the USDA scaled back its efforts to maintain a set of production indices separate from those of the FAO, and cooperation with the FAO increased. Simultaneously, the FAO published a retrospective data series for most commodities and most countries extending back to 1948–50 (FAO, 1987).

[7] The Nigerian National Accounts Survey of the late 1950s is quite explicit about the conjectural nature of its agricultural data. District officers' qualitative reports were converted into percentage increases in output and aggregated over the country to get indices of food crop production. "Much improved from last year," for instance, was converted into a 10 percent increase (Okigbo, 1962). Other evidence indicates that the discrepancies between growth rates reported by

and indirect evidence is at best a series of "consensus estimates" on output growth and variation.

Responses to this situation vary. To some, "Since official aggregate statistics are so problematic, considerable weight must be lent to local-level studies" (Watts 1986, p. 7); while to others "...agricultural production estimates for less-developed countries must be treated with reserve, although we have confidence in the broad trends that they reveal" (Mellor and Johnston, 1984, p. 538). Two points seem relevant in this debate. First, we must note that the record of agricultural performance and production is much richer than it was in the cases of 18th or 19th century development, and the methods used to estimate output are perhaps less appalling when viewed against those (mail questionnaires to farmers and indirect observations) used in the United States as late as the 1950s. Second, in a situation where direct observation is scanty and probably quite unreliable, much is gained by continual monitoring of a wide variety of reporting and corroborative sources. Seeking refuge in a handful of good micro studies evades the need to evaluate the likelihood that estimates of output levels or growth are wrong. In the absence of expensive and concerted efforts to improve the reliability of field-level reporting, the USDA's long-term effort to compile meaningful estimates has probably led to a more reliable record of performance than would otherwise exist.

Berry (1984) raises an additional and serious problem to the interpretation of production statistics in the African context: the possibility of systematic downward bias in production reports due to sales of output across borders and in parallel markets to evade marketing taxes and profit margins of statutory corporations. There is no easy way to insure against such bias, but consistent monitoring of corroborative evidence (i.e., relative price as well as production data) provides a measure of protection against it, as does the use of cross-country analysis to provide consistency checks and identify outliers—which may be due to deviations in statistics-gathering as well as deviations in performance.

Data on production and yields are not the only data crucial to the assessment of agricultural performance; data on the agricultural labor force, land utilization, inputs of materials (fertilizer, for instance, is reported by the FAO), and trade are also important. The International Labor Organization (ILO), working from a series of surveys of population, labor force participation, and labor force allocation, provides decadal estimates of the share of population in the labor force, and of the share of the labor force in agriculture. The ILO estimates reveal another source of discrepancies among figures reported by different agencies: the ILO-reported population figures generally diverge from those reported by the USDA and by

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different agencies for African countries is related to the weight of root crops—yams and cassava—in the national production aggregates (Wells, 1988, pp. 19–22).

the World Bank and International Financial Corporation (1987). For the data employed here, the differences between varying estimates of population growth in the worst case (the discrepancy between the USDA and ILO population growth estimates for Africa in the 1950s) involve an interquartile range of discrepancies in population growth rates of 20 percent.

Given the accuracy of data on specific agricultural outputs, there remains the problem of deriving an appropriate aggregate to represent agricultural performance, a problem that involves accuracy and extent of coverage as well as the selection of appropriate weights. The USDA's approach to this problem is to construct an index based on relatively fewer major crop and livestock components (usually 18–35 crops in developing countries) and to use domestic price weights which (converted into dollars) are published along with their series. The basis of the FAO's indices are not published explicitly, although since 1979 domestic price weights have also supposedly been used.[8] Each of these approaches has its advantages. The FAO series is probably more complete, but at the cost of including unexamined components and of providing no means to examine the sensitivity of the index to specific price or output assumptions. The USDA series, with price weights made explicit and much consideration for movements in the commodity components, does suffer from omission of some commodities, such as livestock in the case of Indonesia—a middle income country whose livestock production may be expected to be increasing rapidly.[9]

The analysis here employs the USDA data series, but derives the aggregates of production independently by applying the USDA reported prices to their components. The alternative use of the FAO statistics would require considerable additional data in the form of price weights used, and would involve questions about the consistency of the series over long periods of time. In my opinion the USDA's consistent coverage of output over a 35-year period makes it the series of choice for analyzing long-term trends in agricultural output and its major components.

AGRICULTURAL PERFORMANCE SINCE 1950

Tables 1 through 5 present an overview of the agricultural experience of a sample of 82 developing countries over the past 30–35 years, as shown by the USDA indices of gross agricultural product and the ILO's estimates of the share of the labor force in agriculture from 1950 through 1980.[10]

[8] Before 1979 regional price weights were used to derive the FAO aggregates.

[9] A comparison the author made covering the USDA's commodity components for Indonesia and those in the FAO *Food Balance Sheets* for 1980 indicates that, even with the omission of livestock, the USDA estimates pick up more than 92 percent of agricultural production.

[10] Countries are identified in Appendix Table A.3. The reader should note that

Table 1 records the percentage distribution of per capita agricultural growth by country over the 1950–85 period, together with median values by country grouping for per capita growth and agricultural instability. Table 2 shows the median values of the basic parameters characterizing agricultural growth over the 30-year period between 1950 and 1980.[11]

In the absence of individual estimates of per capita GNP growth in each of the 82 countries, the results of Table 1 must be read against typical estimates of the growth of per capita output and, thus, of predicted agricultural demand. The (exponential) per capita growth rates of .008 and .012 reflect lower bound estimates of demand growth from the historical record of per capita income growth and from the Lluch, Powell, and Williams (1975) income elasticities of demand (.6–.8 in the early stages of development).[12]

The results must be interpreted with caution, for they are not measures of adequacy of performance by country. But the impression gained from Table 1 is that over the time period involved most countries have not shown agricultural growth rates high enough to meet the rates implied by Johnston-Mellor adequacy. Forty percent of the country cases examined show negative per capita growth between 1950 and 1985, and in two-thirds of the countries production per capita grew at less that the 0.8 percent minimum estimate of required growth. The figures are only slightly less inadequate when the 1950–80 period is selected, leaving out the poor Sub-Saharan African performances of the early 1980s.

The distribution of cases over country groupings is of some interest. For Asia and (to a lesser extent) Latin America the number of low growth cases is reduced in the 1970s, but for Sub-Saharan Africa the proportion of low performances steadily increases from the 1950s, when Sub-Saharan countries turned in the best levels of agricultural growth.

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only 69 countries are included in the tests for patterns of agricultural growth incorporating measures of per capita income, and that gross agricultural product refers to the sum of commodity outputs weighted by domestic prices. The value added in agriculture is derived by deducting imputed values of domestic or imported livestock feed and inputs from other sectors from gross agricultural product (Wells, 1988, p. 10).

[11] The figures for agricultural growth between 1950–80 are averages of decadal data: output values regressed on time for 1950–59, 1960–69, and 1970–79. While these averages are consistent with the ILO's decadal reporting of labor force change in agriculture, they will differ slightly from growth rates derived by regressions on time for the full 30-year period.

[12] A 1 percent rate of per capita income growth with a 0.8 income elasticity of demand would lead to the .8 percent increase in expected agricultural demand, and a 2 percent increase in per capita income with a 0.6 income elasticity of demand leads to the 1.2 percent growth of demand.

Table 1.—Distribution of Per Capita Agricultural Growth, Median Values of Per Capita Agricultural Growth (a^*), and Coefficients of Variation (CV)

	1950–85[a]	1950–80[b]	1950s	1960s	1970s
All countries (82 countries)					
$a^* < 0$ (*percent*)[c]	40	31	29	38	45
$\leq +.008$ (*percent*)	67	61	47	60	62
$\leq +.012$ (*percent*)	83	71	61	66	70
a^* – median	.003	.005	.009	.003	.003
CV – median	.065	.039	.041	.033	.041
Subsaharan Africa (28 countries)					
$a^* < 0$ (*percent*)[c]	54	32	21	32	61
$\leq +.008$ (*percent*)	79	71	29	57	82
$\leq +.012$ (*percent*)	89	79	39	64	86
a^* – median	–.002	.004	.014	.005	–.003
CV – median	.071	.042	.037	.035	.041
Asia (15 countries)					
$a^* < 0$ (*percent*)[c]	27	27	33	47	33
$\leq +.008$ (*percent*)	33	47	47	53	40
$\leq +.012$ (*percent*)	73	60	67	67	53
a^* – median	.010	.008	.009	.005	.011
CV – median	.055	.036	.040	.031	.043
Latin America, Caribbean (25 countries)					
$a^* < 0$ (*percent*)[c]	36	32	32	44	40
$\leq +.008$ (*percent*)	76	68	72	72	60
$\leq +.012$ (*percent*)	88	76	84	76	68
a^* – median	.002	.004	.003	.001	.005
CV – median	.059	.036	.034	.031	.043
North Africa, Middle East (14 countries)					
$a^* < 0$ (*percent*)[c]	36	29	36	29	36
$\leq +.008$ (*percent*)	64	43	43	50	50
$\leq +.012$ (*percent*)	71	57	57	100	57
a^* – median	.004	.010	.009	.010	.009
CV – median	.113	.066	.067	.076	.071

Source: U.S. Department of Agriculture data base; see text, footnote 1.

[a]USDA data used to calculate both agricultural and population growth.

[b]USDA data used to calculate agricultural growth; growth rates of population computed by averaging decadal growth rates from International Labor Organization, *Labour Force Projections, 1950–2000*, Geneva, 1984.

[c]Cumulative percent of cases less than value indicated.

Examination of the coefficients of variation show the highest median value in the North African and Middle Eastern countries followed by Sub-Saharan Africa (Table 1).

Table 2 provides a further characterization of the differences (in median country performance) among country groupings. Growth rates of product per agricultural worker, highest in the North African and Middle Eastern group of countries, are offset by high (i.e., more negative) rates of decline in the share of the labor force in agriculture in this group. The much lower growth rates of productivity per agricultural worker of the Sub-Saharan group is also offset by lower (less negative) rates of decline in the agricultural share of the labor force. Whether this informal observation reflects a substantial difference between the growth patterns of the country groupings requires the more formal analysis of the patterns of agricultural growth with respect to development.

The analysis of these patterns (Tables 3A and 3B) is essentially a descriptive one carried out on the assumption that the key processes underlying agricultural growth rates are significantly related to levels of development as proxied by per capita income. To capture these relationships, the variables describing per capita agricultural growth are first regressed on Chenery and Syrquin's variables of per capita income and population to define the development patterns (1975). Subsequent regressions add other variables that are potentially seen as modifying these patterns, here dummy variables for the country groupings, and (in Tables 4 and 5) the population growth variables seen as capturing Boserup effects.

The method of deriving basic patterns varies from that employed by Chenery and Syrquin in one significant way: the country experience covered is only that of developing countries. The advanced industrial economies—and those of the Soviet Union and eastern Europe—are left out of the analysis on the grounds that the growth of their agricultural sectors reflect conditions quite different from those conditioning the growth of agriculture in developing countries. The omission of high income countries simplifies the Chenery-Syrquin patterns considerably; the best forms of the regression involves simply the (natural) log of per capita income; population (size) is not a significant predictor of any of the variables shown in Tables 3–5, and square terms in the log of per capita income are not significant.

The basic patterns are seen in Tables 3A and 3B.[13] Both the growth of output per agricultural worker (π^*) and the rate of change in the agricultural labor force as a share of the population (λ^*) vary with the level of development, proxied by per capita income in 1965 dollars, which explains about a quarter or a third of the variation in π^* and λ^* for the 69-country sample. The use of dummies to proxy the country groupings

[13] The forms of the regressions in Tables 3A and 3B parallel those of Chenery and Syrquin (1975).

Table 2.—Median (Country) Values for Growth Rates of Agricultural Output Per Capita (a^*), Output per Agricultural Worker (π^*), Share of Agriculture in the Labor Force (λ^*), and Population (P^*) *

	1950–80	1950s	1960s	1970s
All countries (82)				
a^*	.005	.009	.003	.003
π^*	.021	.023	.017	.018
λ^*	−.015	−.013	−.015	−.015
P^*	.025	.024	.025	.025
Sub-Saharan Africa (28)				
a^*	.004	.014	.005	−.003
π^*	.011	.021	.013	.008
λ^*	−.007	−.005	−.007	−.009
P^*	.024	.019	.024	.029
Asia (15)				
a^*	.008	.009	.005	.011
π^*	.022	.023	.015	.023
λ^*	−.013	−.012	−.015	−.009
P^*	.022	.021	.024	.023
Latin America, Caribbean (25)				
a^*	.004	.003	.001	.005
π^*	.023	.023	.022	.025
λ^*	−.018	−.018	−.019	−.018
P^*	.027	.028	.025	.024
North Africa, Middle East (14)				
a^*	.010	.009	.010	.008
π^*	.032	.033	.035	.040
λ^*	−.023	−.019	−.023	−.028
P^*	.028	.027	.029	.026

Source: Production data from U.S.Department of Agriculture data base; see text, foonote 1. Agricultural labor force and population data from International Labor Organization, *Labour Force Projections, 1950–2000*, Geneva, 1984.

* Note that $a^* = \pi^* + \lambda^*$.

indicates significant differences in these patterns for the North African and Middle Eastern group of countries: growth of per worker product is significantly higher and the rate of decline in the agricultural share of the labor force significantly higher (more negative) than would be predicted on the basis of per capita income (Equations (3.1B) and (3.2B)). Once the deviations characterizing the NAME countries are recognized, however, the other country groupings do not appear to differ at a 5 percent level of significance from the common patterns for π^* and λ^*.[14] The level of development (as represented by per capita income) is also a significant predictor of both population growth (P^*) and output growth (A^*), but it explains little (less than 8 percent) of the variation in the values of these variables (Equations (3.3A) – (3.4B)).

Tables 4 and 5 represent the simplest possible formulation for a test of the Boserup effect: does the level of output growth in agriculture, taking into account the level of development as proxied by per capita income, vary (positively) with population growth? Equations (4.1A) and (4.1B) indicate that it does—and imply a growth elasticity of agricultural output with respect to population of greater than 1.0.[15] Equations (4.2) and (5.1) represent tests of one way in which the Boserup effect might be seen as working: higher rates of population growth leading to high rates of growth of the agricultural labor force (L^*) and, through the production function, to higher rates of output growth (A^*). The growth of the agricultural labor force is seen to be significantly related to both $ln(y)$ and P^*, especially when the different performance of the North African and Middle Eastern countries are taken into account. The link between growth of the labor force and growth of output shows F values that are less significant (but still significant at a 5 percent level), and implies an output elasticity with respect to labor force growth of about .3 or .4.

Equations (4.2) and (5.1) do not reflect a formal test of the Boserup effect as it is formulated by those attempting to model its workings. To test the far more subtle hypotheses involving the development of infrastructure or the switching of production regimes would require far better specification of an aggregate agricultural production functions than is possible with the country-level data available here. It is interesting, however, to note the strong basic association between population growth and the growth of

[14] The dummy variable for Asia shows a higher growth of output per worker at about an 8 percent level of significance. The SSAF dummy is significant at a 5 percent level for λ^* when SSAF is considered alone. This significance evaporates when the NAME dummy is also present.

[15] Note (Equations 4.1A and 4.1B) that when population growth is introduced as a predictor of agricultural output growth, a term involving the square of the log of per capita income also becomes significant in predicting the relationship between $A*$ and the level of development.

Table 3A.—Structural Relationships Among Growth of Per Worker Product (π^*), Change in the Share of the Agricultural Force (λ^*), Population Growth (P^*), and 1965 Per Capita Income (y) *
(69-country sample)

Dependent	(3.1A) π^*	(3.1B) π^*	(3.2A) λ^*	(3.2B) λ^*
C	−.0435	−.0431	.0320	.0231
	(−3.110)	(−2.231)	(4.055)	(2.297)
$ln(y)$	.0127	.0115	−.0095	−.0073
	(4.691)	(3.439)	(−6.237)	(−4.183)
SSAF		.0011		.0012
		(.193)		(.413)
ASIA		.0129		−.0032
		(1.791)		(−.932)
NAME		.0187		−.0139
		(3.273)		(−4.728)
F	22.010	10.158	38.900	20.660
Sig.	(.000)	(.000)	(.000)	(.000)
R^2	.236	.350	.358	.536

Source: Production data from U.S. Department of Agriculture data base; see text, footnote 1. Agricultural labor force and population data from International Labor Organization, *Labour Force Projections, 1950–2000*, Geneva, 1984. Per capita income (y) data in 1965 dollars from Hollis B. Chenery and Moises Syrquin, *Patterns of Development: 1950–70*, Oxford University Press for the World Bank, New York, 1975.

Variables: π^* =annual growth of per worker productivity, 1950–80; λ^* = annual change in share of the population in the agricultural labor force; y = per capita income in 1965 dollars.

* t-values in parentheses. SSAF, ASIA, NAME are dummy variables indicating Sub-Saharan Africa, Asia, North Africa and the Middle East, respectively.

agricultural output that appears to be present in the historical data.

CONCLUDING OBSERVATIONS

The results of the empirical survey presented above may be summarized quite simply. The findings appear to constitute a strong case for the presence of a shortage phase in contemporary (i.e., post–World War II) patterns of agricultural development; they also give some credence to Boserup's claim about the impact of more rapid population growth on agri-

Table 3B.—Structural Relationships Among Growth of Per Worker Product (π^*), Change in the Share of the Agricultural Force (λ^*), Population Growth (P^*), and 1965 Per Capita Income (y) *
(69-country sample)

Dependent	(3.3A) $A^*(30)$	(3.3B) $A^*(35)$	(3.4A) $P^*(30)$	(3.4B) $P^*(35)$
C	.0020	.0020	.0135	.0146
	(.168)	(.193)	(2.798)	(3.109)
$ln(y)$	.0056	.0052	.0024	.0021
	(2.419)	(2.553)	(2.578)	(2.358)
SSAF[a]				
ASIA[a]				
NAME[a]				
F	5.852	6.519	6.646	5.560
Sig.	(.014)	(.013)	(.012)	(.021)
R^2	.067	.075	.077	.063

Source: Production data from U.S. Department of Agriculture data base; see text, footnote 1. Agricultural labor force and population data from International Labor Organization, *Labour Force Projections, 1950–2000*, Geneva, 1984. Per capita income (y) data in 1965 dollars from Hollis B. Chenery and Moises Syrquin, *Patterns of Development: 1950–1970*, Oxford University Press for the World Bank, New York, 1975.

Variables: $A^*(30)$ = annual growth of agricultural output, 1950–80; $A^*(35)$ = annual growth of agricultural output, 1950–85; $P^*(30)$ = annual growth of population, 1950–80, International Labor Organization estimate; $P^*(35)$ = annual growth of population, 1950–85, U.S. Department of Agriculture estimate; y = per capita income in 1965 dollars.

* t values in parentheses. SSAF, ASIA, and NAME are dummy variables indicating Sub-Saharan Africa, Asia, North Africa and the Middle East, respectively.

[a]None of the dummy variables proved significant for these regressions, so they were dropped.

cultural output. The data upon which these judgments are based are, to a considerable extent, carefully developed consensus estimates of the growth of the components of agricultural output. As such they reflect a great deal of contextual information about agriculture in the countries involved and less firm and reliable data from field surveys of agricultural output.

The interaction between the problems of collecting country-wide data on agricultural output and those of interpreting the data in terms of agricul-

Table 4.—Test for the Boserup Effect of Population Growth (P^*) on Growth of Agricultural Output (A^*), and the Agricultural Labor Force (L^*) *
(69-country sample)

Dependent	(4.1A) $A^*(30)$	(4.1B) $A^*(35)$	(4.2A) $L^*(30)$	(4.2B) $L^*(30)$
C	.1045	.0725	.0329	.0218
	(1.812)	(1.573)	(3.923)	(2.093)
$ln(y)$	−.0447	−.0340	−.0093	−.0075
	(−1.981)	(−1.878)	(−5.806)	(−4.189)
$ln^2(y)$	.0045	.0034		
	(2.104)	(2.007)		
$P^*(30)$	1.3408		.9305	1.1041
	(5.145)		(4.626)	(6.293)
$P^*(35)$		1.4867		
		(6.938)		
SSAF[a]				.0011
				(.374)
ASIA[a]				−.0032
				(−.929)
NAME[a]				−.0412
				(−4.720)
F	12.008	19.830	21.420	17.626
Sig.	(.000)	(.000)	(.000)	(.000)
R^2	.327	.454	.375	.550

Sources: Production data from U.S. Department of Agriculture data set; see text, footnote 1. Agricultural labor force and population data from International Labor Organization, *Labour Force Projections, 1950–2000*, Geneva, 1984. Per capita income (y) data in 1965 dollars from Hollis B. Chenery and Moises Syrquin, *Patterns of Development: 1950–70*, Oxford University Press for the World Bank, New York, 1975.

Variables: $A^*(30)$ = annual growth of agricultural output, 1950–80; $A^*(35)$ = annual growth of agricultural output, 1950–85; $P^*(30)$ = annual growth of population, 1950–80; $P^*(35)$ = annual growth of population, 1950–85; y = per capita income.

*t values in parentheses. SSAF, ASIA, and NAME are dummy variables indicating Sub-Saharan Africa, Asia, and North Africa and the Middle East, respectively.

[a]Dummies all insignificant in equations predicting A^* and hence have been dropped.

Table 5.—Boserup Effects: Agricultural Output Growth (A^*) and Labor Force Growth (L^*) *
(69-country sample)

Dependent variable	(5.1A) $A^*(30)$	(5.1B) $A^*(30)$
C	−.0183	.0940
	(−.992)	(1.358)
$ln(y)$	.0081	−.0358
	(2.571)	(−1.364)
$ln^2(y)$		.0042
		(1.682)
$L^*(30)$	.3221	.3962
	(1.982)	(2.284)
SSAF	.0027	.0013
	(.518)	(.254)
ASIA	.0098	.0098
	(1.624)	(1.647)
NAME	.0115	.0123
	(2.141)	(2.304)
F	2.730	2.812
Sig.	(.027)	(.017)
R^2	.113	.138

Source: Production data from U.S. Department of Agriculture data base; see text, footnote 1. Agricultural labor force and population data from International Labor Organization, *Labour Force Projections, 1950–2000*, Geneva, 1984. Per capita income (y) data in 1965 dollars from Hollis B. Chenery and Moises Syrquin, *Patterns of Development: 1950–1970*, Oxford University Press for the World Bank, New York. 1975.

Variables: $A^*(30)$ = annual growth rate of agricultural output, 1950–80; $A^*(35)$ = annual growth of agricultural output, 1950–80; $P^*(30)$ =annual growth of population, 1950–80; $P^*(35)$ = annual growth of population, 1950–85; y = per capita income.

* t values in parentheses. SSAF, ASIA, and NAME are dummy variables indicating Sub-Saharan Africa, Asia, and North Africa and the Middle East, respectively.

tural performance raises two questions that need to be taken into account in appraising these findings. The first of these relates to the validity of any analysis resting on such shaky foundations, the second to the role of large cross-sectional studies in evaluating underlying data and setting priorities for improvement in data collection.

To the extent that inadequate reporting introduces elements of random error into reported levels or rates of growth of output, the statistical techniques used—especially in the Chenery-Syrquin analysis of income-related patterns—can assign measures of confidence to hypotheses set forth on the basis of the shaky data. These techniques do not, however, protect against the existence of systematic bias, as in the possible underreporting of African agricultural growth that is the subject of Berry's (1984) concern.[16] Protecting against such systematic bias is a task requiring not only improved censuses and sample surveys but—in addition—the contextual type of data gathering done over the past 35 years by the USDA analysts. Where efforts to amass and evaluate corroborative data are absent there is a danger that increasingly inaccurate country data may be accepted from field surveys.

There is another point involved in appraising the validity of country data where the type of cross-sectional analysis carried on here may be of use. By identifying outliers from typical patterns of agricultural development such analysis can spot situations that may reflect anomalies in data collection or in country-specific conditions. An example from the regression analysis reported in Tables 3–5 may illustrate this point. In each of the regressions involving output and productivity growth the same outliers were identified: Jordon, Korea, and Libya as having much higher than predicted rates of productivity growth; and Mozambique, Angola, and Ghana as having much lower than predicted rates. At the low end of the scale, the cases of Mozambique and Angola become clear in the light of the civil wars of the late 1970s and 1980s, but performance of Ghana up to 1985 reads so poorly in the light of the typical patterns as to deserve further examination. A first step in the analysis of the Ghanian record would involve the decomposition of aggregate growth into its components and identification of the lagging subsectors.

Even taking into account the limits of the data used, this survey of agricultural performance since World War II yields somewhat surprising results. The occurence of shortage phases in the agriculture of developing economies does seem greater than expected, and the details and implications of agricultural shortages appear to deserve more examination than they have received to date.

[16] It may be of interest in evaluating Berry's concern—which involves both the underreporting of output growth and the tendency to view all of Sub-Saharan Africa as a case of agricultural crisis—that dummy variables to find whether the SSAF patterns of productivity and output growth over the 35-year period differ from the typical pattern do not show significant differences. For decadal data, however, there is some evidence that African productivity growth is below that expected on the basis of income in the 1970s (Wells, 1985).

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Appendix Table 1.—Growth of Per Capita Agricultural Output (a^*) by Country, 1950–85

Annual growth rate[a]										
> .003	SUR	(.033)								
.020 to .030	ISR	(.029)	SAU	(.028)	MLY	(.023)	ROK	(.023)	CPY	(.022)
.012 to .019	MWI	(.019)	IVC	(.018)	ZAM	(.017)	PRC	(.016)	ECU	(.014)
	VEN	(.014)	LBY	(.013)	TWN	(.012)	TUN	(.012)	THL(.012)	
	ZBE	(.012)								
.008 to .011	GUA	(.011)	CAM	(.011)	PAK	(.011)	MEX	(.010)	PHL	(.010)
	INS	(.010)	BRM	(.009)	BRZ	(.009)	VNM	(.009)	KEN	(.008)
	PAN	(.008)								
0 to .007	TNZ	(.007)	IND	(.005)	BOL	(.005)	MDG	(.005)	IRN	(.005)
	COS	(.005)	NIC	(.005)	RSA	(.004)	TUR	(.004)	LEB	(.004)
	COL	(.003)	ARG	(.003)	BRN	(.003)	NIG	(.003)	GUI	(.003)
	GUY	(.002)	ELS	(.002)	PAR	(.001)	CUB	(.001)	SYR	(.001)
	BKF	(.000)	HON	(.000)						
−.005 to 0	SRL	(−.001)	ETH	(−.002)	SLE	(−.002)	EGY	(−.002)	LIB	(−.003)
	JAM	(−.003)	RWA	(−.004)	MOR	(−.004)	MLI	(−.004)	IRQ	(−.004)
	CHL	(−.004)	SUD	(−.005)	URU	(−.005)	BSH	(−.005)	DRP	(−.005)
< −.005	ZAI	(−.006)	TRT	(−.006)	AFG	(−.007)	BEN	(−.007)	NEP	(−.008)
	TOG	(−.008)	JOR	(−.008)	NGA	(−.008)	SEN	(−.010)	PER	(−.010)
	UGA	(−.011)	HAI	(−.012)	ANG	(−.013)	GHA	(−.014)	BRB	(−.105)
	MOZ	(−.016)	ALG	(−.018)						

Source: U.S. Department of Agriculture data set; see text, footnote 1. For country codes, see Appendix Table A.3.

[a]Exponential growth rates.

(*a**) by Country, 1950–80

Annual growth rate[b]										
> .03	ISR	(.035)	KOR	(.033)	SUR	(.030)				
.02 to .03	PRC	(.029)	CYP	(.028)	MWI	(.028)	NIG	(.027)	IVC	(.021)
	LBY	(.021)								
.012 to .019	ECU	(.019)	SAU	(.017)	GUA	(.015)	ZAM	(.015)	TWN	(.014)
	CAM	(.014)	VNM	(.013)	JOR	(.013)	ARG	(.013)	TNZ	(.013)
	PHL	(.013)	BRZ	(.013)	TUR	(.013)	PAN	(.012)	MLY	(.012)
	VEN	(.012)								
.008 to .011	IRN	(.011)	MEX	(.011)	BUR	(.010)	RSA	(.009)	IRQ	(.009)
	ISN	(.009)	PAK	(.008)	JAM	(.008)				
0 to .007)	BOL	(.007)	TUN	(.006)	GUI	(.006)	ZBE	(.006)	KEN	(.006)
	PAR	(.006)	SLE	(.005)	THA	(.005)	COL	(.005)	AFG	(.004)
	ELS	(.004)	ZAI	(.004)	SYR	(.004)	BKF	(.004)	COS	(.004)
	MAL	(.004)	HON	(.004)	MDG	(.003)	IND	(.003)	NIC	(.002)
	BEN	(.001)	SEN	(.001)	LIB	(.001)	GUY	(.000)		
−.005 to −.001	TRT	(−.001)	MOR	(−.001)	TOG	(−.001)	EGY	(−.001)	SUD	(−.002)
	BRM	(−.003)	SRL	(−.004)	LEB	(−.004)	CHL	(−.004)	ETH	(−.005)
< −.005	RWA	(−.006)	CUB	(−.006)	DRP	(−.006)	BRB	(−.008)	NEP	(−.009)
	BSH	(−.010)	URU	(−.011)	NGA	(−.013)	PER	(−.014)	ALG	(−.016)
	HAI	(−.020)	MOZ	(−.021)	ANG	(−.021)	UGA	(−.023)	GHA	(−.021)

*Agricultural production growth calculated by author using data from U.S. Department of Agriculture data base; see text, footnote 1. Population growth calculated by author using data from International Labor Organization, *Labour Force Projections, 1950–2000*, Geneva, 1984.

[a]Growth rates are averages of decadal growth rates for 1950–59, 1960–69, and 1970–79.

Appendix Table 3.—Country Names and Identification Codes and Definitions of Variables

Code	Country	Code	Country	Code	Country
AFG	Afghanistan	HON	Honduras	PHL	Philippines
ALG	Algeria	IND	India	PRC	People's Republic
ANG	Angola	INS	Indonesia		of China
ARG	Argentina	IRN	Iran	RSA	Republic of
BEN	Benin	IRQ	Iraq		South Africa
BKF	Burkina Faso	ISR	Israel	RWA	Rwanda[a]
BOL	Bolivia	IVC	Ivory Coast	SAU	Saudi Arabia
BRB	Barbados[a]	JAM	Jamaica	SEN	Senegal
BRM	Burma	JOR	Jordon	SLE	Sierra Leone
BRN	Burundi[a]	KEN	Kenya	SRL	Sri Lanka
BRZ	Brazil	KOR	Korea	SUD	Sudan
BSH	Bangladesh[a]	LBY	Libya	SUR	Surinam[a]
CAM	Cameroun	LEB	Lebanon	SYR	Syria
CHL	Chile	LIB	Liberia	TAI	Taiwan
COL	Colombia	MDG	Madagascar	THL	Thailand
COS	Costa Rica	MEX	Mexico	TNZ	Tanzania
CUB	Cuba[a]	MLI	Mali	TOG	Togo
CYP	Cyprus[a]	MLS	Malaysia	TRT	Trinidad and
DRP	Dominican	MOR	Morocco		Tobago[a]
	Republic	MOZ	Mozambique	TUN	Tunisia[a]

ECU	Ecuador	MWI	Malawi	TUR	Turkey
EGY	Egypt	NEP	Nepal[a]	UGA	Uganda
ELS	El Salvador	NGA	Nigeria	URU	Uruguay
ETH	Ethiopia	NIC	Nicaragua	VEN	Venezuela
GHA	Ghana	NIG	Nigeria	VNM	Vietnam[a]
GUI	Guinea	PAK	Pakistan	ZAI	Zaire
GUA	Guatemala	PAN	Panama	ZAM	Zambia
GUY	Guyana[a]	PAR	Paraguay	ZBE	Zimbabwe
HAI	Haiti	PER	Peru		

[a]Country not included in cross-section regressions.