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THE AGRICULTURAL TRANSFORMATION IN SUB-SAHARAN AFRICA:

A PROGRESS REPORT

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ABSTRACT

This study provides a progress report on the agricultural transformation in Sub-Saharan Africa. The identifiable phases of agricultural transformation include rising agricultural productivity, and the progressive integration of agriculture in a country's macroeconomy. This study provides empirical measures of both aspects of African development. Taking agriculture's contribution to economic growth as a proxy for its integration into the macroeconomy, this study finds that agriculture has become less, rather than more, integrated. Agriculture's contribution to economic growth in Sub-Saharan Africa has declined strongly over the past 25 years. As regards agricultural productivity, however, there is reason for guarded optimism that Africa is entering the first phase of agricultural transformation. The study provides evidence of positive growth in agricultural factor productivity, and, in some cases, increasing rates of productivity growth over time.

EXECUTIVE SUMMARY

This study provides a progress report on the agricultural transformation in Sub-Saharan Africa. The agricultural transformation is a central component of the broader process of economic development. Characterized by the simultaneous decline in agriculture's relative importance to the economy and a rapid increase in agricultural output, the agricultural transformation is driven by increases in agricultural *productivity* and by the progressive integration of agriculture into a country's macro economy.

In this study, Sub-Saharan Africa's progress towards agricultural transformation is assessed from an empirical basis. Two questions in particular guide the analysis: 1) What have been the trends in agricultural factor productivity? and 2) How successful have African countries been in integrating agriculture into their macro economies?

The report is structured in two parts corresponding to these questions. Part I addresses the question of agriculture's integration into the region's macro economies by examining agriculture's contribution to economic growth, as well as by examining the relationship between countries' agricultural labor productivity and the productivity of the total labor force. Part II provides a detailed analysis of agricultural productivity trends across various commodities and regions of Sub-Saharan Africa. These measurements describe both partial productivity ratios and changes in total factor productivity.

Agriculture's contribution to economic growth serves as proxy for agriculture's integration into the macro economy. The empirical results of the model applied in this study are both perplexing and troubling: while agriculture accounted for 43 percent of the total economic growth in a sub-sample of African countries from 1965 to 1973, that contribution fell to only 14 percent from 1973 to 1980, and agriculture actually *impeded* economic growth in the sample countries by as much as 17 percent from 1980 to 1987.

The contribution of economic productivity in general in these countries followed a similar path. From 1965 to 1973, productivity growth accounted for nearly half of total economic growth. Yet, that contribution fell to only 12 percent from 1973 to 1980, and was *negative* 5 percent from 1980 to 1987. This implies that during the early and mid-1980s, virtually all of the economic growth in those countries resulted from simply using more inputs without any increase in the productivity of those inputs. In particular, during that period nearly all of the economic growth resulted from adding more labor to the economies.

This growth accounting exercise strongly highlights the central role that agriculture must continue to play in Africa's economic development. In the period from 1965 to 1973, when agricultural output in the sample countries grew by over 25 percent, their economies grew by 45 percent. In contrast, from 1980 to 1987, when agricultural output grew by only 9 percent, those economies grew by under 16 percent, just over one-third of their earlier rate. Given these

findings, *the logic of the agricultural transformation points strongly to a focus on agricultural productivity as the linchpin in African economic growth.*

These results also reflect a dramatic disassociation of agriculture from the macro economies of the sample countries over the past 25 years. In terms of agricultural transformation, this suggests that Africa has fallen further from attaining an advanced stage in the process.

These results are reinforced by an examination of the relationship between agricultural labor productivity and the productivity of the total labor force of various countries in Sub-Saharan Africa. Comparing the relative rates of growth in these two areas provides further insight as to the operating condition of agriculture's links to the overall economy. For instance, applying this perspective to countries in Asia and the Near East, one finds clear patterns.

Fast-growing countries, such as Thailand, Turkey, and Malaysia tended to have relatively rapid rates of labor productivity growth in both agriculture and the general economy. While total labor productivity tended to grow more rapidly than agricultural labor productivity in those countries, the gap between the two tended to be small. The slower-growing economies of South Asia had relatively low rates of growth in both types of labor productivity, though the growth rate of agricultural labor productivity was often substantially lower than the rate for the entire economy.

In stark contrast to the Asian examples, these same relationships within Sub-Saharan African countries—many of which experienced negative per capita income growth—reveals a seemingly total disassociation between agricultural and aggregate labor productivity trends. Most of the African countries experienced at least temporary labor productivity losses in one or both measures of labor productivity.

As a group, the African countries, from 1965 to 1973, experienced similar relative rates of agricultural and total labor productivity growth as the slow-growing South Asian countries during the same period. While the South Asian countries changed little over time, Sub-Saharan Africa tended to suffer reductions in the growth rates of both total and agricultural labor. During both 1973-80 and 1980-87, agricultural productivity growth was slightly negative on average, though the rate of decline seemed to bottom out during the 1980s. Total labor productivity grew progressively more slowly over the later two periods, though remained slightly positive in the 1980s.

The broad implication of this finding is that rural welfare has tended to decline relative to total welfare since 1965, and that rural welfare has suffered absolute declines since 1973.

In general, these results reinforce the implications of the previous findings with regard to agriculture's contribution to economic growth: Sub-Saharan Africa has in general fallen further from attaining the stage of agricultural transformation in which agriculture becomes progressively integrated into a country's macro economy.

The agricultural transformation, however, begins with increased agricultural productivity, which Part II of this study measures in detail.

The report adopts two analytical perspectives on measuring changes in agricultural factor productivity. The first approach, primarily graphical, distinguishes average output per agricultural laborer and average output per hectare, and illustrates the relative rates of change in the two. The second approach follows from the econometric estimation of production functions using panel data. Having several time observations on the same cross section of countries permits one to distinguish shifts in the production function from movements along the production function. While the latter implies higher levels of input use, the former indicates changes in factor productivity.

The first of these approaches is known as *partial* productivity analysis, since it identifies the specific contribution of land and labor productivity, but in each case does so without controlling for changes in other factors. The second approach measures changes in *total* factor productivity. This measures, not the specific productivity changes of individual factors, but the generalized increase in efficiency with which producers combine all inputs. This approach has the advantage of controlling for changes in the intensity of input use. The concept of technical change underlies both measures of growth in agricultural factor productivity.

The results of the partial productivity analysis illuminate various components of the challenges for agricultural productivity in Africa. In the aggregate, both average yield and labor productivity increased during the 1970s, as measured by total agricultural value added *in dollars*. Yet, these same measures turn dramatically downward from 1980 to 1989, with productivity losses in both land and labor. The net change from 1970 to 1989, measured in dollars, suggests that labor productivity fell and yields were no greater in 1989 than they had been in 1970.

Repeating this analysis in local currency, however, demonstrates that much of the downturn of the 1980s in total agricultural value added was the result of nominal exchange rate devaluations. In local currency terms, selected examples suggest that yields continued to increase through the 1980s, and that changes in labor productivity were relatively small in either direction. In general, this result is also borne out by commodity-specific partial productivity measures based on physical quantities.

This comparison illustrates that the problem of agricultural productivity in Sub-Saharan Africa has several components, including, not only technical change, but commodity and foreign exchange markets as well. Indeed, these market-oriented factors may be even greater challenges to agricultural productivity in Sub-Saharan Africa than the need for continuing technical change. Technical change has played a positive role in African agriculture, at least in terms of yields. Yet, the race between technical change and population growth, as measured by trends in average labor productivity, has been less positive. The nominal exchange rate devaluations that accompanied the structural adjustment programs of the 1980s, however, presents a substantial obstacle to value added agricultural productivity.

An alternative measure—total factor productivity (TFP)—describes the change in output resulting from productivity growth in all inputs combined. While this measure does not distinguish between the contributions of land and labor, it has the conceptual advantage of distinguishing between output growth resulting from the use of more inputs and growth resulting from greater productivity of those inputs.

The results presented in this study permit several broad generalizations regarding continent-wide TFP trends across commodities. During the 1980s, productivity growth continent-wide was positive in four of the five commodities examined in this study, the sole exception being coffee. Comparing the 1970s to the 1980s, however, one finds that productivity in three of the commodities—maize, coffee, and roots and tubers—grew more slowly than during the previous decade.

In terms of annual average rates of productivity growth from 1968 to 1988, coffee, again, is the only commodity to suffer productivity losses. Factor productivity in rice, and cotton each grew by just under 1 percent per year on average over the two decades. Maize and roots and tubers experienced average annual productivity growth of approximately half that rate, while average coffee productivity change was just slightly negative over the period.

A productivity increase of 1 percent per year is by no means negligible. It contributes to growth in the total output of those commodities 1 percent beyond the increase in the quantity of inputs allocated. These findings, then, justify guarded optimism regarding Africa's progress towards the first phase of agricultural transformation. African agriculture, as represented by maize, rice, coffee, cotton, and roots and tubers, has become more productive over time. Total factor productivity in rice and cotton in particular increased rapidly between 1978 and 1988.

Nonetheless, there still remain several causes for concern. Productivity growth in African agriculture has been uneven, both across commodities and across regions. East Africa has performed relatively well, while West and Southern African agricultural productivity growth has been less promising. Moreover, the instances of productivity gain seen in many regions and commodities during the 1980s were necessary simply to compensate for widespread productivity *losses* during the 1970s.

An additional cause for concern arises from looking back at the trends in partial productivity ratios underlying these *total* factor productivity results. Those findings indicated that most of the productivity gains resulted from *yield* increases. Agricultural labor productivity in Sub-Saharan Africa has been largely stagnant.

In general, however, positive movements in the partial productivity ratios were in a direction characterized by output growth rates roughly equal to population growth rates. Increased labor inputs and land-saving technical change resulted in greater yields with little change in labor productivity.

This is particularly troubling vis-a-vis AID's concern for "people-level impacts." In Sub-Saharan Africa, people-level impacts must largely address the welfare of agricultural laborers. For them, there can be no sustainable welfare gains without technical change to increase average labor productivity. To date, no such change has occurred.

This empirical investigation of Africa's progress in agricultural transformation is a first step towards developing a fuller understanding of the role of agricultural productivity in promoting general economic growth in Africa. The agricultural productivity measurements presented in this study provide the analytical and empirical foundation necessary for developing a model to investigate the economic growth implications of agricultural productivity change in Africa. Such a model would need to capture the effects of inter-sectoral resource transfers intrinsic to agricultural transformation, as well as the forward and backward linkages between agriculture and industry that sustain the growth process. The development of such a model is the ultimate goal of this research.

1. INTRODUCTION

A striking fact emerges from international comparisons of agricultural productivity. From the 1960s to the 1980s, nearly every country in the world experienced increases in agricultural output, measured both per hectare and per agricultural laborer; yet, during the 1970s Sub-Saharan Africa (SSA) dramatically broke ranks, its agriculture becoming progressively less productive by *both* measures. This problem lies at the heart of the region's economic crisis. More specifically, these productivity trends seemed to indicate that the agricultural transformation was unlikely to occur in Africa.

The agricultural transformation is a central component of the broader process of economic development that has been widely observed across countries and over time.[1] This transformation has two general characteristics. The first is that agriculture's share in a country's labor force and total output declines as per capita incomes increase. In short, despite being the dominant sector in most pre-industrial economies, agriculture becomes progressively less important in a country's economy as development proceeds.

The second broad characteristic of agricultural transformation is that agricultural output must increase in a rapid and sustainable manner either before or during general economic growth. Analysts at the World Bank and elsewhere have identified a strong correlation between the rates of agricultural and economic growth. Looking at the 1970s, for example, a World Bank study observed,

> Among countries where the agricultural share of GDP was greater than 20 percent in 1970, agricultural growth in the 1970s exceeded 3 percent a year in 17 of the 23 countries whose GDP growth was above 5 percent a year. During the same period, 11 of the 17 countries with GDP growth below 3 percent a year managed agricultural growth of only 1 percent or less. Agricultural and GDP growth differed by less than two percentage points in 11 of 15 countries experiencing moderate growth.[2]

Viewed together, these two broad features of the agricultural transformation seem paradoxical: fewer and fewer resources are devoted to agriculture as development proceeds; yet, rapid increases in agricultural output are a necessary precondition for development (at least in most countries). Historically, the resolution to this apparent paradox has come through technical change in agriculture. The agricultural transformation, and by extension economic development, are driven (among other things) by technical change that increases the *productivity* of resources remaining in the agricultural sector.

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[1] See Timmer (1988) for a comprehensive discussion of agricultural transformation.

[2] World Bank (1982), cited in Timmer (1988).

Timmer identifies four distinct phases of agricultural transformation:[3]

1) Agricultural productivity per worker rises;
2) Surplus resources created by rising agricultural productivity shift into non-agricultural development;
3) Agriculture becomes progressively more integrated into the general economy; and,
4) Society industrializes; agriculture plays a role similar to any other sector.

Increasing agricultural productivity drives this process. In practice, the borders between these phases of agricultural transformation are hazy. What is clear, however, is the sequential dependence of each phase on the preceding one. Agricultural surpluses cannot be transferred into non-agricultural activities without sustainable increases in agricultural productivity. Similarly, agriculture will not become more integrated into the macroeconomy without that transfer of resources. Indeed, that transfer cannot continue if agriculture does not become more integrated in that way. Finally, our notion of an industrialized society is to a large extent defined by the occurrence of the previous three stages of agricultural transformation. One benchmark might be that less than 20 percent of the labor force remains in agriculture. For instance, in the U.S., less than 2 percent of the labor force remains in agriculture, while in African the average remains approximately 70 percent.

The importance of agricultural productivity to the development process is widely recognized. A recent study by the International Food Policy Research Institute has observed, "A decreasing trend in the growth of agricultural income, resulting from a declining trend in the growth of land and labor productivity, constitutes a major constraint, not only to improved standards of living in the farm sector but also to the development of agriculture and the rest of the economy."[4]

The link between agricultural factor productivity and sustainable growth is also a central theme of the World Bank's recent study of SSA's development prospects. In outlining its strategy for sustainable growth in Africa, the World Bank identifies agriculture as "...the primary foundation for growth." In order to achieve a target agricultural growth rate of 4 percent per year, the World Bank calculates that agricultural labor productivity must increase by 1.5 percent per year and that the productivity of cultivated land must increase by 3 percent per year.[5] The agricultural transformation provides a conceptual framework for these issues.

Broadly, this study seeks to provide empirical measures of Sub-Saharan Africa's progress towards agricultural transformation. Two questions in particular guide the analysis: 1) What

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[3] Timmer (1988)

[4] Tshibaka (1990), p. 7

[5] World Bank (1989)

have been the trends in agricultural factor productivity? and, 2) How successful have African countries been in integrating agriculture into their macroeconomies? These questions, in effect, measure Africa's development vis-a vis the first and third phases of agricultural transformation.

This study presents the results of the first phase of a research project to examine trends in agricultural factor productivity, and to model the relationship between those trends and economic growth in Sub-Saharan Africa. This phase of the work concentrates on measuring agriculture's contribution to economic growth in Africa and on analyzing factor productivity at the level of individual commodities and sub-regions in Africa. These analyses provide a firm foundation for the next phase of the research project, the ultimate goal of which is to construct a policy-relevant simulation model which traces the determinants of agricultural productivity through to their effect on aggregate economic growth.

The analysis of these issues draws upon several data sources. In particular the productivity analysis is based on data published by the FAO. The overall quality and reliability of the FAO data is often criticized. This data is reported to the FAO by governments. While many of the criticisms of the FAO data may be justified, there is no substitute for such data given this study's need for consistent cross-country observations at several points in time. The best one can do is to understand the limitations of the data and to interpret the results accordingly. Data issues and assumptions are discussed in detail in Appendix A.

The report is structured in two parts corresponding to the two questions raised above. Part I addresses the question of agriculture's integration into the macroeconomy by examining agriculture's contribution to economic growth in Sub-Saharan Africa, as well as by examining the relationship between countries' agricultural labor productivity and the productivity of the total labor force. Part II provides a detailed analysis of agricultural productivity trends across the continent, applying two alternative methods for measuring factor productivity.

PART I—AGRICULTURE IN THE MACROECONOMY

2. AGRICULTURE'S CONTRIBUTION TO ECONOMIC GROWTH IN SUB-SAHARAN AFRICA

A central feature of agricultural transformation is the progressive integration of agriculture into a country's macroeconomy. One indicator of this progress is the extent to which agriculture contributes to general economic growth.

The early literature on agricultural transformation and more recent analyses of growth linkages clearly point to the role of inter-sectoral resource transfers in contributing to aggregate growth. Recent work by E.C. Hwa provides a starting point for this discussion.[6]

Hwa suggests that agricultural growth contributes to overall economic growth through its favorable impact on total factor productivity (TFP).[7] His argument for including agricultural growth as an influence on TFP rests on sectoral linkages. In short, Hwa argues that: 1) rapid agricultural growth facilitates the transfer of resources from agriculture to industry by relaxing the constraint on industrial employment imposed by food's role as a wage good, and 2) high agricultural growth reflects high average labor productivity in agriculture, supported by a high quality of human and physical capital. He further argues that the growth of exports and inflation also influence TFP growth (positively and negatively, respectively).[8]

Hwa thus proposes a model in which TFP growth is a function of agricultural growth ($\dot{A}$), export growth ($\dot{X}$), and inflation ($\dot{P}$).[9] Substituting this definition into a Cobb-Douglas aggregate production function, $\dot{Y} = \beta_1 \dot{K} + \beta_2 \dot{L} + \dot{TFP}$, Hwa estimates the function

$$\dot{Y} = \beta_0 + \beta_1 \dot{K} + \beta_2 \dot{L} + \beta_3 \dot{A} + \beta_4 \dot{X} + \beta_5 \dot{P} + \varepsilon \qquad (1)$$

where the average rate of growth in capital is proxied by the average investment rate ($\dot{K}$).

This specification of the determinants of aggregate economic growth is immediately problematic with regard to the estimate for agricultural growth, since it must also be the case

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[6] Hwa (1988)

[7] The concept of total factor productivity is developed in greater depth in Appendix D and in Chapter 5.

[8] See Hwa (1988), p. 1332 for details.

[9] A dot over a variable indicates the rate of growth of that variable.

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that $\dot{Y} = \omega_A \dot{A} + (1 - \omega_A)\dot{N}$, where ω_A is the share of agriculture in GDP, and $\dot{N}$ is the growth rate of the non-agricultural sector. That is, aggregate GDP growth is a weighted average of the growth in agriculture and non-agriculture. Having agricultural growth on the right-hand side of model creates an identity problem for Hwa.

This identification problem, however, fails to explain the changes over time in the estimated coefficient for agricultural growth found in estimating Hwa's model with African data. Table 1 compares Hwa's results using a cross-section of 42 primarily non-African developing countries for the 1960s and 69 non-African developing countries for the 1970s with efforts to recreate his model with African data from three periods.

TABLE 1 Agriculture's Contribution to Economic Growth Dependent Variable: Rate of Growth in GDP

	Africa 1965-73	Africa 1973-80	Africa 1980-87	Hwa 1960-70	Hwa 1970-79
constant	1.42 (1.06)	1.03 (.456)	.257 (.108)	.896 (1.0)	-.139 (0.1)
$\dot{K}$	.032 (.615)	.098 (1.62)	.112 (1.33)	.059 (1.8)	.098 (2.7)*
$\dot{L}$	.380 (.806)	.723 (.981)	.962 (1.01)	.302 (0.8)	.625 (2.0)*
$\dot{X}$	.207 (2.58)*	.152 (2.61)*	.293 (2.54)*	.132 (3.9)*	.235 (5.1)*
$\dot{P}$	-.328 (-1.84)*	-.029 (-.448)	-.011 (-.278)	-.036 (1.5)	-.022 (2.6)*
$\dot{A}$	.676 (5.16)*	.329 (.980)	-.302 (-1.23)	.622 (4.2)*	.380 (4.2)*
$\bar{R}^2$	.832	.343	.541	.66	.61
n	19	19	19	42	69

(t-statistics in parentheses)
* = significant at .05 level

The most striking feature to emerge from the regressions with African data is the trend over time in the coefficient on agricultural growth. For 1965-73, the African estimate is quite close to Hwa's for 1960-70. Indeed, with the exception of inflation, all of the African estimates are reasonably close to Hwa's for the first period. We both find that a one percent increase in the rate of agricultural growth is associated with a .6 - .7 percent increase in the rate of growth of total GDP.

Hwa's estimate falls to .38 for the period 1970-79, which he attributes to structural transformation in his sample countries.[10] Yet, the same coefficient estimated for African data, while highly significant for the earlier period, falls by half in magnitude and is statistically insignificant for 1973-80. For the period 1980-87, agricultural growth relates negatively to economic growth in Africa, though again, this relationship is not statistically significant. This result cannot be explained by changes in the structure of production in Africa, where the average percent of GDP in agriculture was 43 in 1965, 30 in 1980, and 34 in 1987.[11]

One can also extend these results to decompose economic growth into the percentage contributions of growth in agriculture, exports, inflation, capital, and labor. Table 2 presents this decomposition. One calculates the contribution of a given factor to growth by multiplying the estimated coefficient for that factor (from Table 1) by the percent change in that factor over the period.

Thus, for example from Table 2, from 1965-73 capital (investment) increased by 89.1 percent. Multiplying that by the estimated coefficient (.032) indicates that capital accounted for 2.9 *percentage points* of the 45 percentage points by which GDP grew during that period. Growth in capital thus accounted for 6 *percent* of the total growth in GDP during that period. The contribution of "inputs" in Table 2 is the sum of labor and capital; the contribution of "productivity" is the sum of the individual contributions of agriculture, exports, and inflation.

Several interesting findings emerge from Table 2. As the estimates in Table 1 suggest, *agriculture's contribution to economic growth in Sub-Saharan Africa has fallen dramatically since 1965*. During the first period (1965-73), agriculture accounted for 43 percent of all economic growth in the 19 Sub-Saharan African countries in this sample.[12] From 1973-80, however, agriculture's contribution to economic growth fell to only 14 percent; and, from 1980-87, agriculture actually *impeded* economic growth, diminishing economic growth by 17 percent.

In this sample of countries, total economic growth slowed dramatically over the course of these three periods, falling from 45 percent from 1965-73, to just over one-third of that amount from 1980-87. There was a more rapid decline in the contribution of productivity, *as defined in the Hwa model*, to economic growth.

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[10] One should note, however, that Hwa's regressions are not strictly comparable across periods since the two regressions use different samples of countries.

[11] World Bank (1989), Appendix Table 3

[12] The size of this sample was limited to include only those countries for which each variable was available for all three periods. While more countries could have been included in a given year, this would compromise the comparability of the results across periods. Doing so, however, does not change the nature of the results.

TABLE 2 African Growth Accounting of Hwa's Model

Explanatory Variable		Est. coef (1)	1965-1973 % Change in explanatory variable (2)	1965-1973 Contribution to growth (percentage) (3)=(1a)*(2)	1973-1980 % Change in explanatory variable (4)	1973-1980 Contribution to growth (percentage) (5)=(1b)*(4)	1980-1987 % Change in explanatory variable (6)	1980-1987 Contribution to growth (percentage) (7)=(1c)*(6)
INPUTS				10.1 (22%)		15.9 (53%)		14.9 (94%)
Capital	a:	.032						
	b:	.098		2.9		3.0		-2.8
	c:	.112	63.7	(6%)	31.1	(10%)	-24.6	(-17%)
Labor	a:	.380						
	b:	.723		7.3		12.8		17.7
	c:	.962	17.5	(16%)	17.8	(43%)	18.4	(112%)
PRODUCTIVITY				21.3 (47%)		3.6 (12%)		-0.9 (-5%)
Agriculture	a:	.676						
	b:	.329		19.5		4.3		-2.7
	c:	-.302	25.1	(43%)	13.1	(14%)	9.1	(-17%)
Exports	a:	.207						
	b:	.152		15.1		3.8		3.8
	c:	.293	54.9	(34%)	24.8	(12%)	13.1	(24%)
Inflation	a:	-.33						
	b:	-.029		-13.3		-4.5		-1.9
	c:	-.011	34.0	(-30%)	154.5	(-15%)	176.2	(-12%)
RESIDUAL				13.6 (30%)		10.7 (35%)		1.8 (11%)
TOTAL GROWTH				45.0 (100%)		30.2 (100%)		15.8 (100%)

From 1965-73, productivity growth accounted for 47 percent for total economic growth in the sample countries. Yet, from 1973-80, productivity change accounted for only 12 percent of economic growth; and the productivity contribution from 1980-87 was negative 5 percent. In the later period, the productivity growth derived from growth in exports was negated by the productivity losses imposed by agriculture and inflation. Economic growth in these countries relied increasingly on simply using more inputs, the contribution of which grew from 22 percent to 53 percent to 94 percent in succeeding periods.[13]

Among inputs, the burden fell increasingly on labor. As investment's contribution to growth increased from 6 percent to 10 percent and then plummeted to negative 17 percent in the 1980s, labor's contribution increased steadily. Indeed, from 1980-87, most of the economic growth in these sample countries can be attributed to increased use of labor.

This growth accounting exercise strongly highlights the central role that agriculture must continue to play in Africa's economic development. In the period from 1965 to 1973, when agricultural output in the sample countries grew by nearly 29 percent, their economies grew by 45 percent. In contrast, from 1980 to 1987, when agricultural output grew by only 9 percent, those economies grew by under 16 percent.

The growth accounting also indicates that during the earlier period, growth in agriculture and in exports together accounted for 77 percent of total economic growth in the sample countries. While export growth continued to contribute to economic growth in later periods, the central role of agriculture in African exports, combined with a decline in agricultural growth, reduced exports' contribution to growth, as well. This suggests that African countries cannot rely on exports to the exclusion of agriculture as a source of economic growth. The precipitous decline in investment growth and its contribution to general economic growth cited above further reinforces the notion that African economies have virtually nowhere else to turn than to agriculture as a source of economic growth.

Given these findings, *the logic of the agricultural transformation points strongly to a focus on agricultural productivity as the linchpin in African economic growth.* The record of African development since 1965, as reflected in these findings, dramatically suggests that donors should retain a strong focus on interventions designed to enhance agricultural productivity, rather than turning hopefully to other sectors to drive growth.

Despite the questions that one might justifiably raise regarding Hwa's underlying model, the dramatic disassociation of GDP growth from agricultural growth in Africa between 1965 and 1987 suggests that something important and troubling happened to African agriculture over that period. By this measure, the progressive integration of agriculture into the macroeconomy—a

[13] The residual in Table 2 reflects some combination of missing inputs and other factors contributing to productivity. From 1965-73, the model explains 69 percent of total growth, though its explanatory power increases to 75 percent from 1973-80 and to 88 percent from 1980-87.

central feature of the agricultural transformation—has not occurred in these sample countries. Indeed, these results suggest that Africa has lost ground rapidly in this regard since 1965.

The questions raised by this finding reinforce the need to investigate in greater depth the role of agriculture in Africa's economic growth. The following chapter provides an alternative perspective on the integration of agriculture into the macroeconomies of Sub-Saharan Africa.

3. LABOR PRODUCTIVITY IN AGRICULTURE AND THE MACROECONOMY

This chapter examines agriculture's integration into the macroeconomy from a different angle. Various aggregate relationships in the economy can provide some insight as to the operating condition of agriculture/macroeconomic linkages. Figure 1, from Timmer (1989), illustrates stylized patterns of growth as described by the relationship between growth in agricultural labor productivity and growth in total labor productivity.

Movements along the 45 degree line would indicate proportionally equal changes in both growth rates. Figure 1 identifies three distinct growth patterns, which Timmer refers to as "+/+ growth," "-/+ growth," and "-/- growth." These distinctions refer to the likely effects on urban-rural income distribution, where the first sign refers to the inter-sectoral income distribution and the second sign refers to the intra-sectoral income distribution.

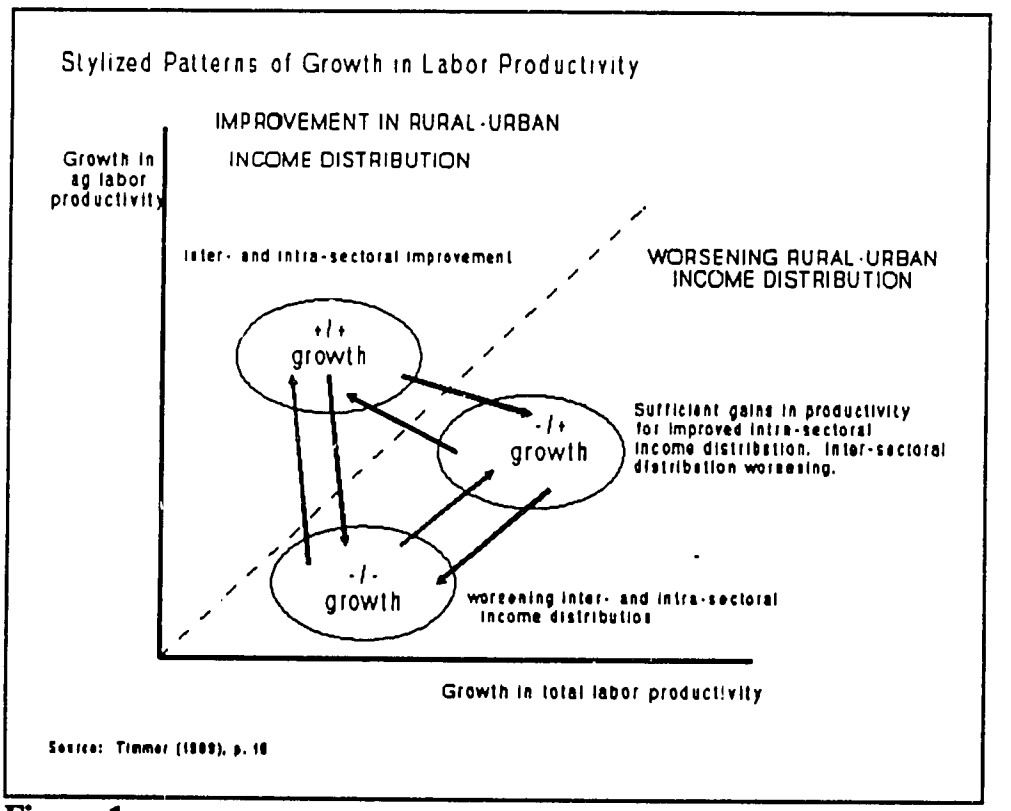


Figure 1

The notion is that relatively rapid increases in agricultural labor productivity (i.e., movements steeper than the 45 degree line) tend to shift income distribution in favor of the agriculture sector. Moreover, rapid productivity increases in both sectors will tend to increase real incomes, thus improving intra-sectoral distribution of income in both sectors, as well. In the "-/+" region, inter-sectoral income distribution shifts towards the industrial sector (presumably a worsening of the income distribution), though real wages are still increasing

sufficiently in both sectors to promote improved intra-sectoral income distribution. The double negative region, conversely, indicates a worsening of both the inter- and intra-sectoral income distribution. The arrows leading between these regions in Figure 1 represent the possible transitional paths described by these associations.

Applying this framework to Asia and the Near East, Timmer finds a set of relationships illustrated in Figure 2. Two clear patterns emerge from Figure 2. One set of countries clusters just below the 45 degree line at relatively high rates of both agricultural and aggregate labor productivity growth. These countries, including Thailand, Turkey, and Malaysia, also experienced strong economic growth over this period. In contrast, the slower-growing South Asian countries, such as Bangladesh, Sri Lanka, and India form a tight cluster in the "-/-" region.

The coherence of the Asian patterns provide an important contrast with the African experience. The details of the varying Asian experiences are less important for present purposes than several broad observations. The first point is simply to note that even the poor performers among the Asian countries are situated in the positive quadrant of Figure 2 in both periods. By the same token, these poor performers maintained positive, if low, per capita rates of growth in GDP during these years. The second point is that in these countries in which growth occurred, there were recognizable relationships between the trends in agricultural labor productivity and aggregate labor productivity.

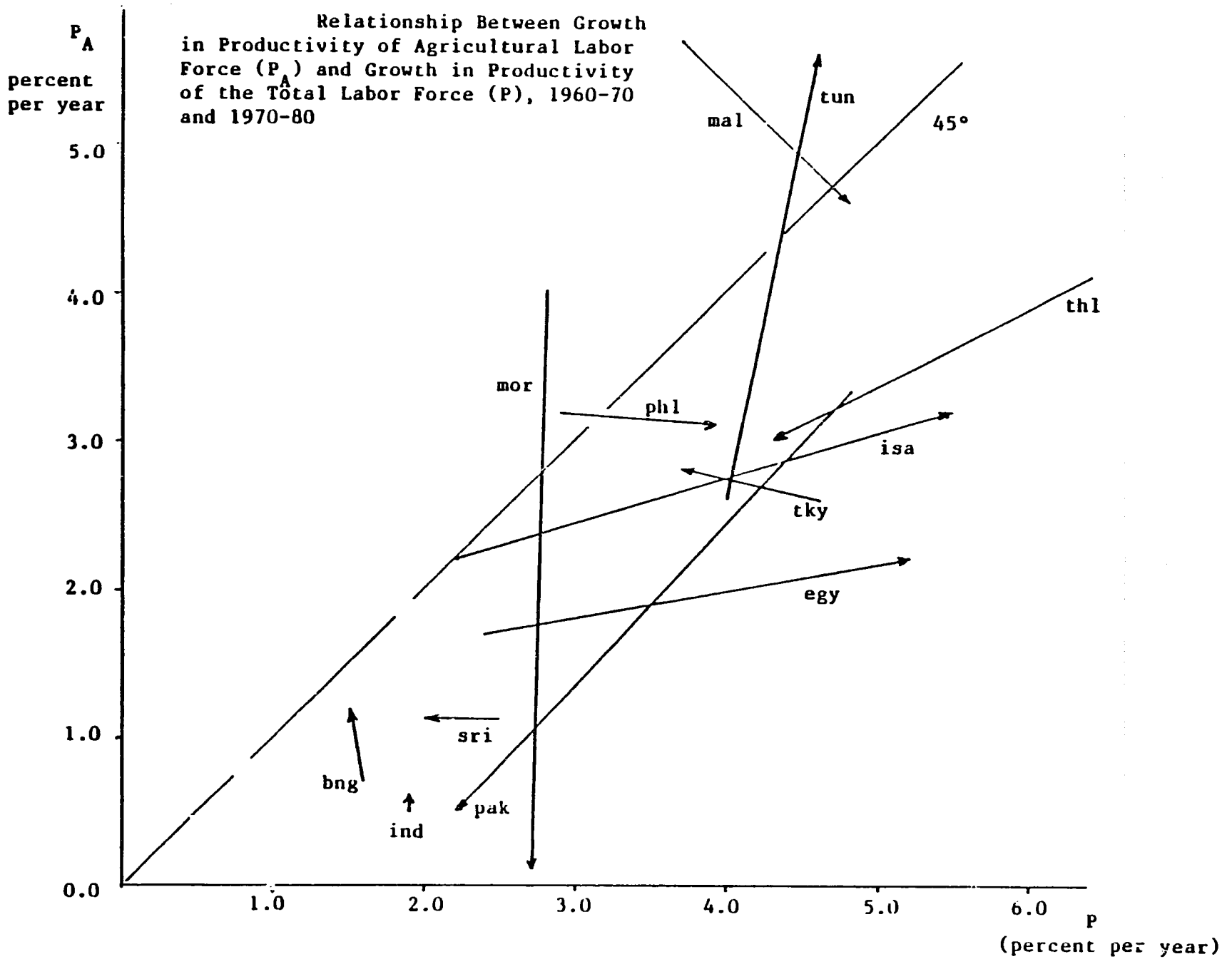
In stark contrast to the Asian examples, these same relationships within Sub-Saharan African countries—many of which experienced negative per capita income growth—reveal a seemingly total disassociation between agricultural and aggregate labor productivity trends. Figure 3 presents the same relationships for five regions of Sub-Saharan Africa and for all five regions together (SSA).[14] With the exception of the Sahelian countries, the trends in both agricultural and total labor productivity across Sub-Saharan Africa are strongly negative.

The transition from 1965-73 to 1973-80 shows four of the regions and the SSA aggregate moving from low to lower rates of labor productivity growth both in agriculture and in the general economy. For East and West Africa, average growth in agricultural productivity from 1973 to 1980 was negative, though total labor productivity in those regions continued to grow slowly during that period. Southern Africa's transition was more dramatic, falling from the relatively strongest position during 1965-73 to negative growth rates of labor productivity in both agriculture and the macroeconomy during 1973-80.

Looking at the average productivity growth rates for 1980-87, East Africa remains negative along both axes of Figure 3; Central and Southern Africa experienced slow but positive growth in total labor productivity and losses (though quite minor for Central Africa) in agricultural labor productivity; and, West Africa was the only region in which agricultural labor

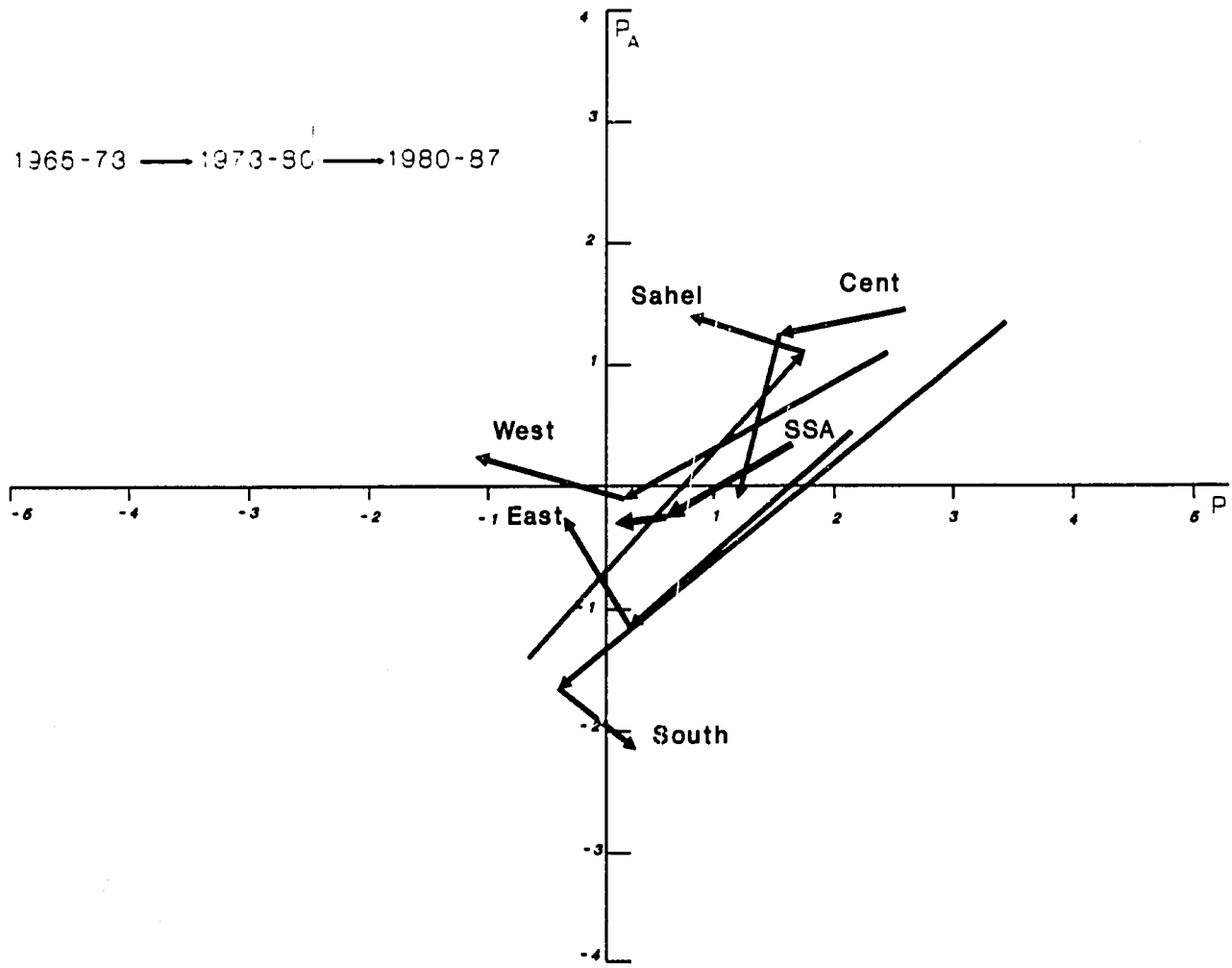
[14] The country-specific results are presented in a series of similar graphs in Appendix F.

FIGURE 2



from Timmer, 1991

FIGURE 3 Growth in Agricultural Versus Total Labor Productivity



productivity increased while total labor productivity decreased (though the rate of change was low in both instances).

The Sahel was the only region to maintain positive labor productivity growth in both of the later two periods, and the only region with positive productivity growth along both axes during 1980-87. The SSA aggregate summarizes these regional movements as having followed a negative trend over time, moving from positive average growth in both agricultural and total labor productivity from 1965-73 to slightly negative growth in agricultural labor productivity and slightly positive growth in total productivity during the later two periods.

Comparing the African results in Figure 3 with the Asian results presented in Figure 2, one finds that the African regions (except for the Sahel) begin their transition in a cluster roughly equivalent to the South Asian cluster in Figure 2 ("-/-" growth in the schematic terms of Figure 1), and proceed downhill from there. The final points in the transition of the African regions lie in a cluster with declining labor productivity by one or both measures for four of the five regions and the SSA aggregate.

The contrast between SSA and the fast-growing South-East Asian countries shown in Figure 2 is striking. The latter countries reflect a pattern in which the agricultural sector is integrated into the macroeconomy in a manner that promotes general economic growth. This relationship is non-existent for the African regional aggregates. Indeed, the African regions *start* in a cluster similar to the slow-growing countries of South Asia, and get worse. These relationships thus sustain the picture of disarticulation between agriculture and the macroeconomies of Sub-Saharan Africa that emerges from the results presented in Chapter 2.

These alternative perspectives on agriculture's integration into the macroeconomies of Sub-Saharan Africa strongly suggest that Africa is far from entering the third stage of agricultural transformation. Chapter 2 found that agriculture's contribution to economic growth has declined substantially over the past 25 years. While one should expect such a trend in the advanced stages of agricultural transformation, Sub-Saharan Africa is clearly not at that point. The distinct absence of a coherent relationship between agricultural and total labor productivity revealed in Chapter 3 reinforces that conclusion.

Within the context of agricultural transformation, the logical next step is to examine more closely Africa's progress towards entering the *first* stage of agricultural transformation—rising agricultural productivity. Part II of this study presents the results of two alternative approaches to measuring agricultural factor productivity.

PART II—MEASURING AGRICULTURAL FACTOR PRODUCTIVITY

Part II of the report adopts two analytical perspectives on measuring changes in factor productivity in African agriculture. The approach taken in Chapter 4, primarily graphical, distinguishes between changes in average output per agricultural laborer and changes in average output per hectare (the "partial productivity ratios"). The second approach, presented in Chapter 5, follows from the econometric estimation of production functions using panel data. Having several time observations on the same cross section of countries permits one to distinguish *shifts* in production from movements *along* the production function. As in Griliches and Jorgenson (1967), we take shifts in the function itself to reflect changes in total factor productivity.

While the first approach distinguishes between changes in land and labor productivity holding nothing constant (hence the term *partial* productivity), the latter approach measures the productivity change in all inputs combined, controlling for changes in the levels of input use. This is referred to as *total* factor productivity.

Appendix A describes the data sources and limitations underlying this analysis. The most problematic treatment of the data comes in response to the need for crop-specific labor allocations based on incomplete information. Appendix A describes in detail the assumptions imposed on the data, as well as their rationale and statistical validity.

4. PARTIAL PRODUCTIVITY RATIOS

The separate measures of average land and labor productivity (Y/A and Y/L respectively) are known as partial productivity ratios. Hayami and Ruttan (1985) present a useful and intuitive conceptual framework for analyzing trends in these ratios, based on the simple identity

$$\frac{Y}{L} \equiv \frac{A}{L} \times \frac{Y}{A} \tag{2}$$

where Y = total quantity produced, A = total area harvested, and L = total agricultural labor force.

Taking logs of both sides, this identity becomes

$$log\left(\frac{Y}{L}\right) \equiv log\left(\frac{A}{L}\right) + log\left(\frac{Y}{A}\right) \tag{3}$$

This identity lends itself to graphical presentation as shown in Figure 4. This figure relates changes over time in land and labor productivity, measuring the log of average labor productivity along the horizontal axis and the log of average yield along the vertical axis.

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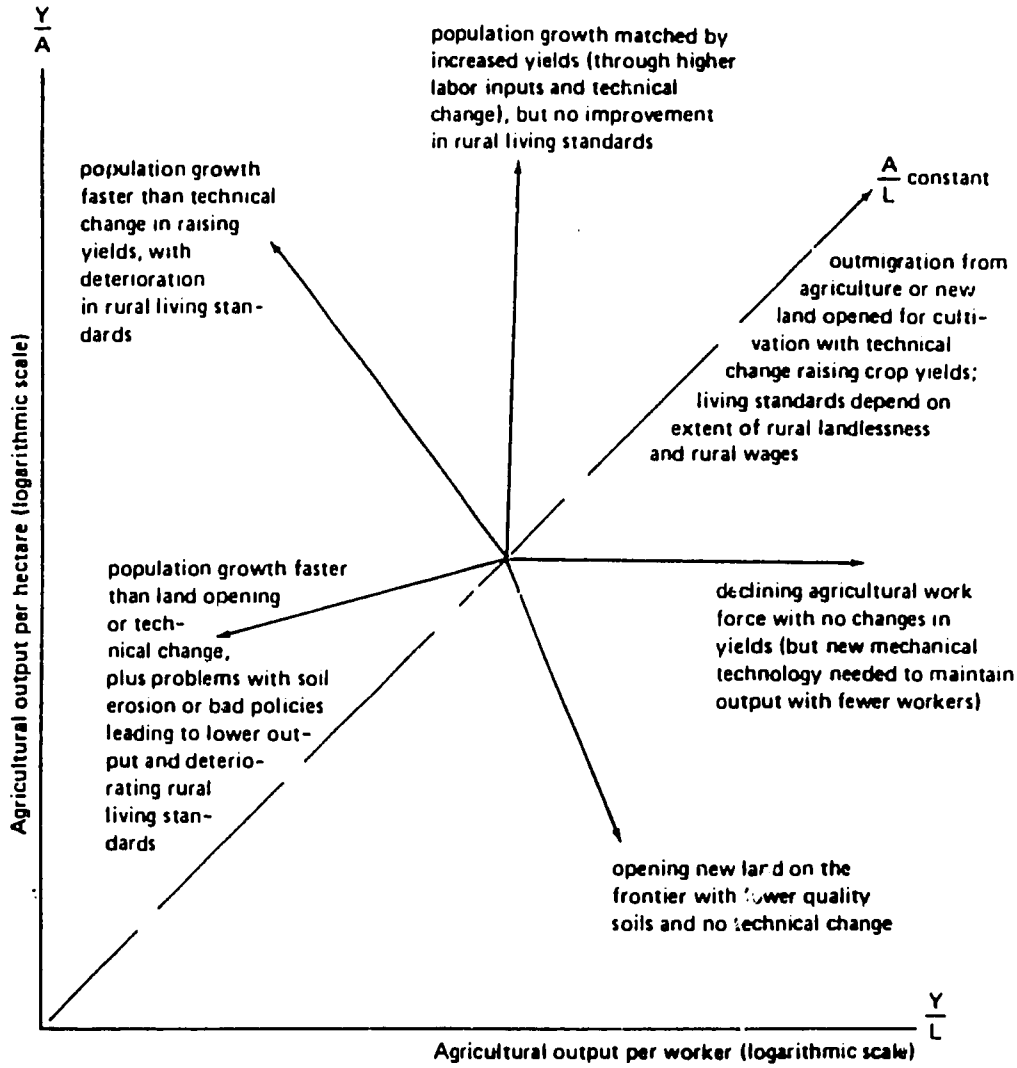
FIGURE 4 Interpretation of Partial Productivity Ratios



from Timmer, based on Hayami and Ruttan (1985)

Changes over time in yield (Y/A) and labor productivity (Y/L) can be illustrated by connecting the level at the beginning and at the end of a given period with an arrow. Such an arrow would simultaneously describe the changes in yield and labor productivity.

Scaling the axes in logs is merely a convenience, implying that equal rates of change in Y/A and Y/L would appear as movements along a 45 degree line. Thus, an arrow that is steeper than the 45 degree line would indicate that yield increased more rapidly than labor productivity in that country.[15]

Figure 4 summarizes the various possibilities for changing land and labor productivities. As Timmer notes, only movements to the right--toward higher output per worker—can improve the welfare of rural workers.[16] Movement directly to the right would imply constant yields attained by a declining agricultural work force (bolstered by new mechanical technology to increase output per worker). As we shall see, a more relevant example for Sub-Saharan Africa is movement down and to the left. As Figure 4 indicates, such a direction would indicate population growth rates in excess of technology's ability to increase output per worker and environmental degradation undermining output per acre. Marginal expansion of production onto poor quality land could also contribute to declining yields.

Hayami and Ruttan's well-known illustration in Figure 5 is based on a cross-section of 44 developed and developing countries, only two of which (Mauritius and South Africa) are from Sub-Saharan Africa.[17] The start of each arrow measures the partial productivity ratio 1960, while the end of each arrow measures the levels for 1980. Their figures describe aggregate agricultural output (measured in "wheat units") as functions of hectares and male agricultural laborers.

For present purposes, the most significant aspect of Figure 5 is that 1) all of the countries benefitted from increases in both land and labor productivity over that period (with the exception of Bangladesh, where labor productivity fell slightly). The following section illustrates that Africa's experience has been more mixed than that of the regions examined by Hayami and Ruttan.

4.1 Aggregate Partial Productivity Ratios for Sub-Saharan Africa

The most general approach to evaluating partial productivity ratios for Sub-Saharan Africa is to look broadly across the entire agricultural sector. Figure 6 does this for the entire continent and for five regional aggregates, taking *agricultural value added* as the output

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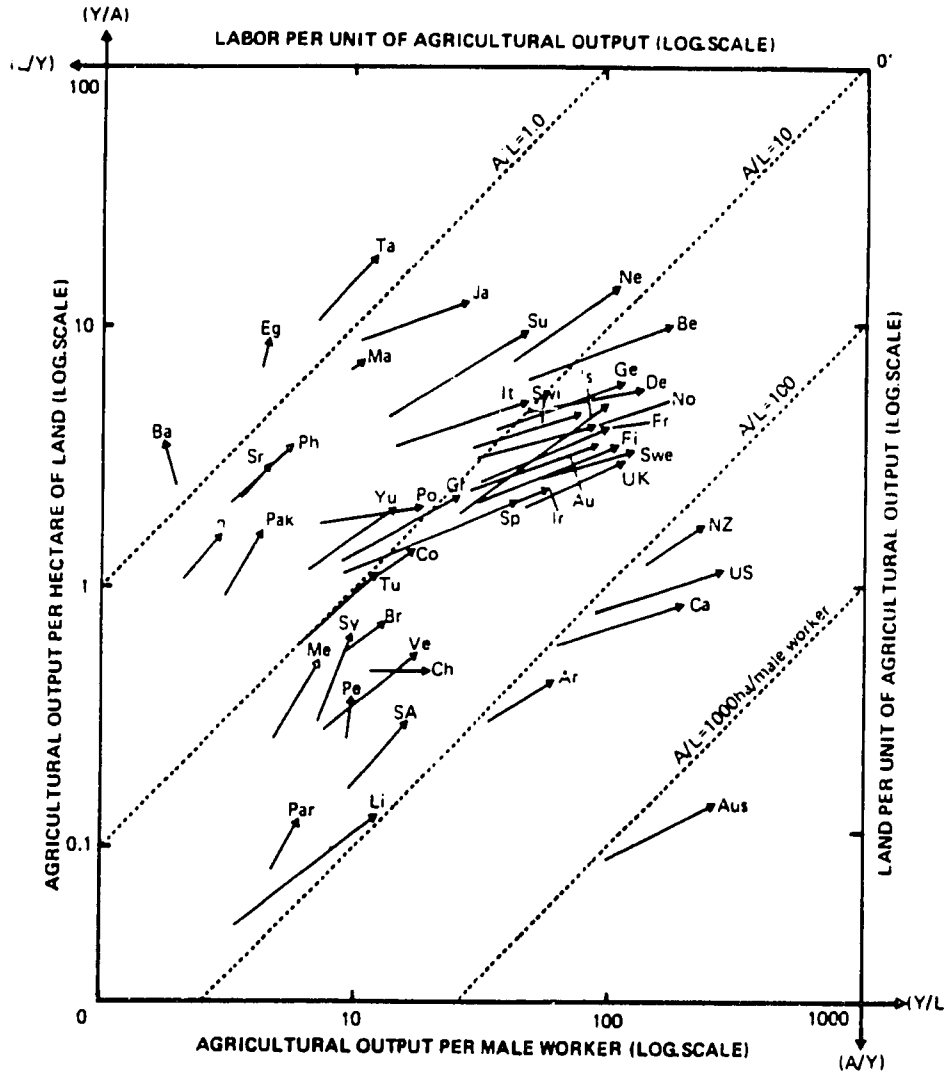
[15] Equation (3) thus suggests that any 45 degree line would measure a constant level of area per worker (A/L), since a given percentage change in yield would fully exhaust an equal percentage change in output per worker.

[16] Timmer (1988)

[17] Our data set excludes South Africa.

FIGURE 5 Partial Productivity Ratios, Worldwide



Key:

Argentina	Ar	Finland	Fi	Mexico	Me	Sri Lanka	Sr
Australia	Aus	France	Fr	Netherlands	Ne	Surinam	Su
Austria	Au	Germany, F.R.	Ge	New Zealand	NZ	Sweden	Swe
Bangladesh	Ba	Greece	Gr	Norway	No	Switzerland	Swi
Belgium	Be	India	In	Pakistan	Pak	Syria	Sy
(& Luxembourg)		Ireland	Ir	Paraguay	Par	Taiwan	Ta
Brazil	Br	Israel	Is	Peru	Pe	Turkey	Tu
Canada	Ca	Italy	It	Philippines	Ph	United Kingdom	UK
Chile	Ch	Japan	Ja	Portugal	Po	United States	USA
Colombia	Co	Libya	Li	South Africa	SA	Venezuela	Ve
Denmark	De	Mauritius	Ma	Spain	Sp	Yugoslavia	Yu
Egypt	Eg						

Hayami and Ruttan (1985)

measure. The first portion of each kinked arrow shows the change in the partial productivity ratios from 1970 to 1980; the second segment indicates changes from 1980 to 1989.[18]

The results in Figure 6 are quite dramatic in their suggestion that Sub-Saharan Africa suffered large losses in both land and labor productivity during the 1980s. These losses, however, followed a decade of substantial gains in both measures of productivity.

In Central Africa and the Sahel, the productivity gains of the 1970s significantly outweighed the losses of the 1980s: in 1989, both regions enjoyed higher levels of both land and labor productivity than they began with in 1970. In contrast, East and West Africa both ended the 1980s at lower levels of both land and labor productivity than they started with in 1970, while Southern Africa in 1989 suffered a net loss in labor productivity and no change in yields over its 1970 levels. The aggregate changes for Sub-Saharan Africa essentially paralleled the Southern African experience.

One must interpret these results with caution. The large nominal devaluations common across the continent in the late 1980s tend to reduce agricultural value added when considered *in dollars*.[19] Thus the sharp downward trends in the 1980s reflect nominal exchange rate movements as well as underlying productivity changes.

Leaving the output measure of agricultural value added in local currencies (though still deflating those values with local currency deflators) eliminates the effects of nominal devaluations on the partial productivity ratios.[20] Figure 7 presents arbitrarily selected examples of local currency value added partial productivity ratios. (The common currency of the CFA zone permits cross-country aggregation in local currency.) These examples suggest that exchange rate movements play a significant role in explaining the quite negative results for the 1980s found in Figure 6.[21]

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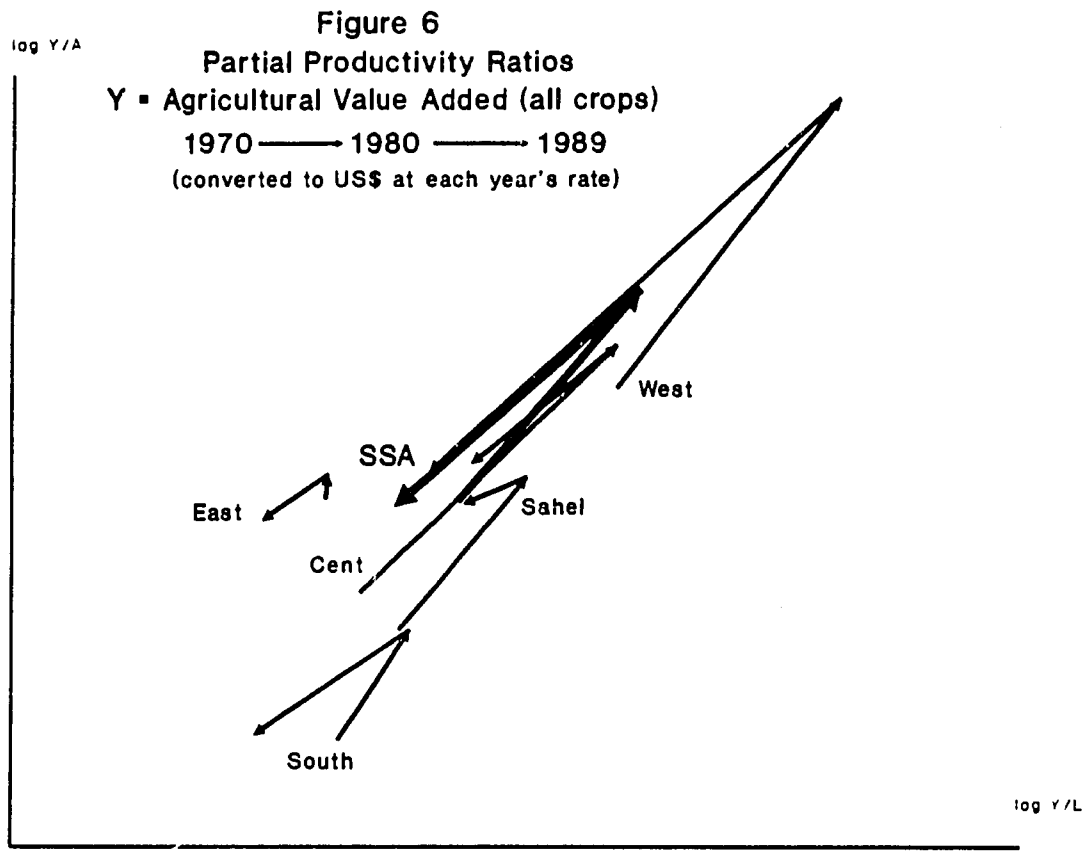
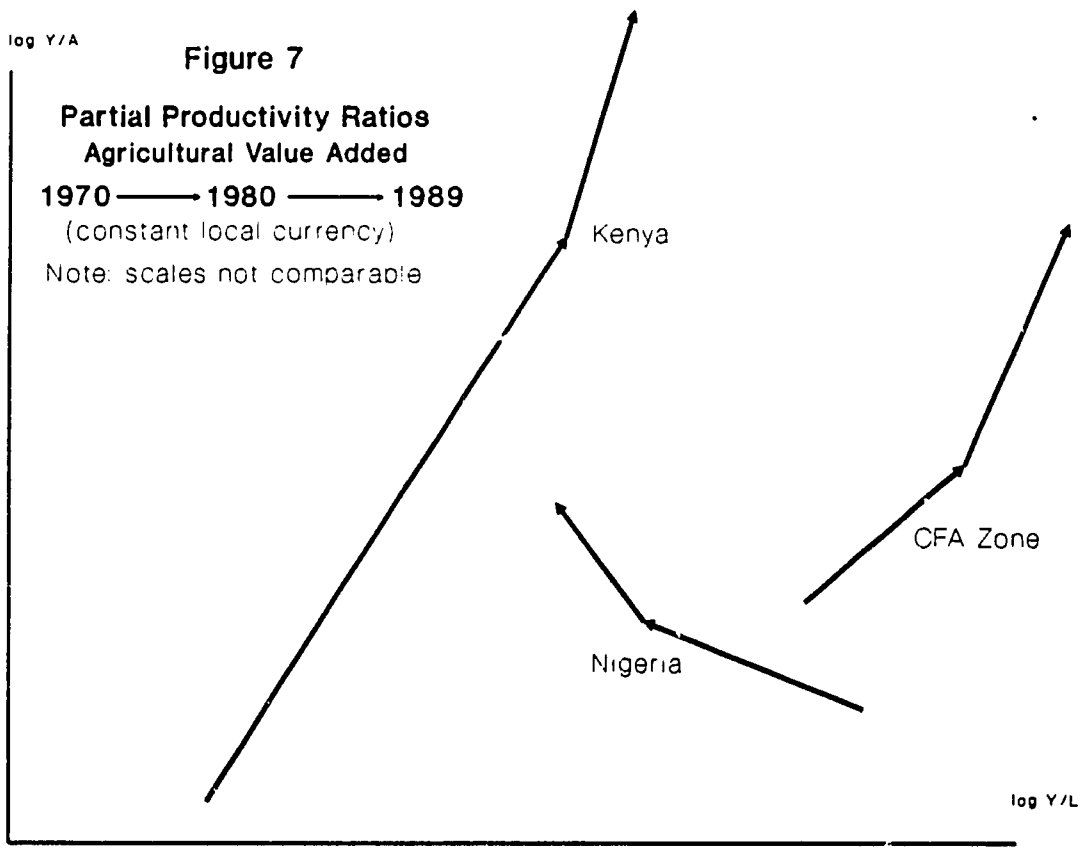
[18] The land and labor figures used in the denominators of these partial productivity ratios apply to the agricultural sector of each country as a whole. This obviates the requirement imposed by the crop-specific analysis presented in the following section to assign specific labor inputs to each commodity. Appendix A describes the methods and assumptions taken for that purpose.

[19] Data for agricultural value added are taken from the World Bank's *World Tables*. Those data are published in local currencies, and were converted to dollars at each year's official exchange rate, and deflated to constant 1987 dollars using the U.S. GDP deflator.

[20] Not converting the values to dollars, however, invalidates cross-country comparisons of levels and magnitudes of change, since the scale is different for each country.

[21] It should be noted, however, that Nigeria, Kenya, and the CFA zone together account for nearly 60 percent of total agricultural value added in Sub-Saharan Africa.


log Y/A
Figure 6
Partial Productivity Ratios
Y = Agricultural Value Added (all crops)
1970 → 1980 → 1989
(converted to US$ at each year's rate)
West
SSA
East
Sahel
Cent
South
log Y/L


log Y/A
Figure 7
Partial Productivity Ratios
Agricultural Value Added
1970 → 1980 → 1989
(constant local currency)
Note: scales not comparable
Kenya
CFA Zone
Nigeria
log Y/L

All three examples in Figure 7 show consistent yield gains in both decades. Those yields gains were more rapid during the 1970s for the CFA countries and Nigeria, and were relatively greater for Kenya during the 1970s. Both Kenya and the CFA countries also experienced gains in labor productivity in both decades, though those gains were more impressive during the 1970s.

In terms of the partial productivity ratios, the smaller magnitude of those labor productivity gains in the 1980s makes them more vulnerable to the nominal devaluations of that decade. Indeed, the differences between Figures 6 and 7 are relatively minor for the 1970s, prior to the large devaluations of the following decade (when Figures 6 and 7 diverge).

The contrast between Figures 6 and 7 illustrates that the problem of agricultural productivity in Sub-Saharan Africa has several components, including, not only technical change, but commodity and foreign exchange markets as well. Figure 7, though very suggestive, leads to the conclusion that these market-oriented factors may be even greater challenges to agricultural productivity in Sub-Saharan Africa than the need for continuing technical change.

Figure 7, along with the findings in the following section, indicate that technical change has played a positive role in African agriculture, at least in terms of yields. Yet, the race between technical change and population growth, as measured by trends in average labor productivity, has been less positive. The nominal exchange rate devaluations that accompanied the structural adjustment programs of the 1980s, however, presented a substantial obstacle to agricultural productivity as measured by internationally comparable value added.

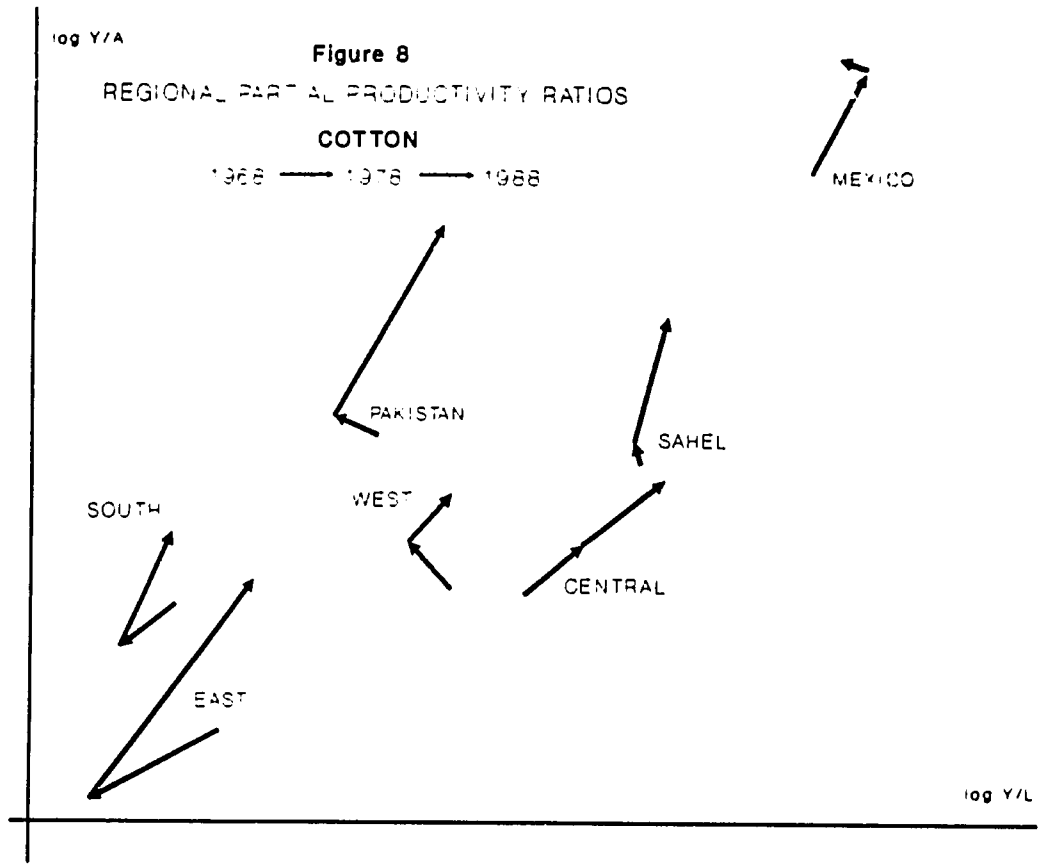
The relatively bleak picture of productivity trends presented in Figure 6 also changes somewhat when the output measure is the quantity of a given crop rather than agricultural value added. Quantity-based partial productivity ratios for five individual commodities are presented in the following section. Those results, though more positive, reveal a substantial degree of heterogeneity across both regions and commodities.

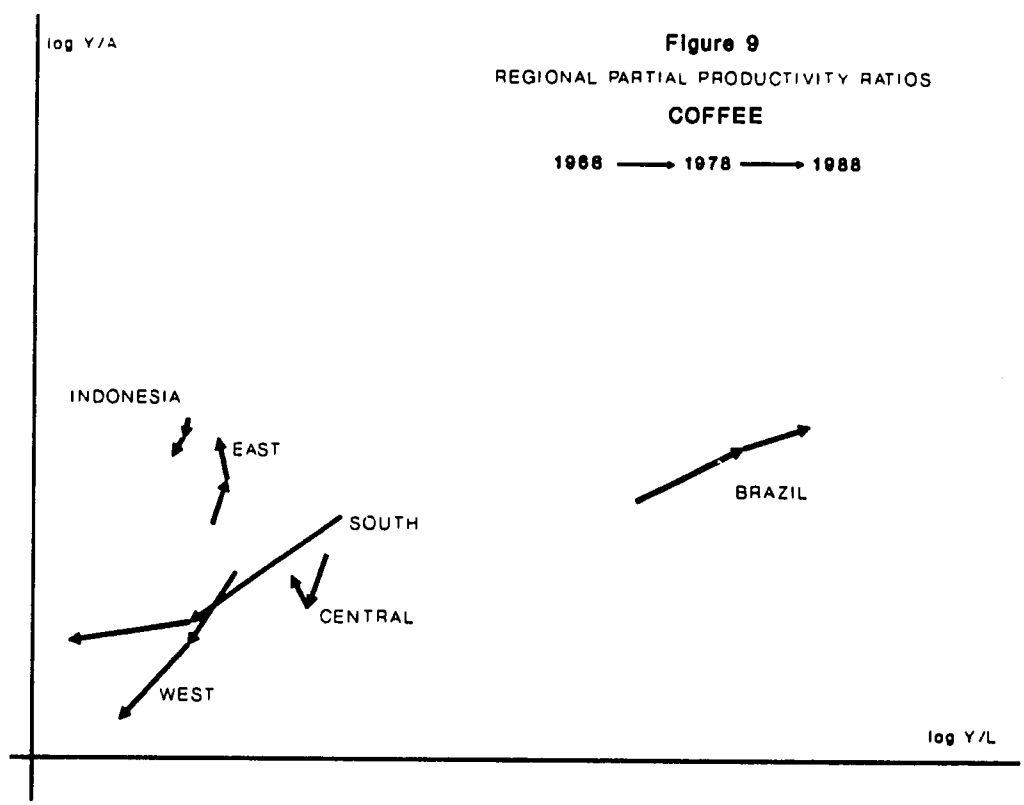
4.2 Partial Productivity Ratios by Region and Commodity

Figures 8 through 12 present disaggregated partial productivity ratios for cotton, coffee, maize, rice, and roots and tubers for two periods and five regions. In addition, Figures 8 through 12 juxtapose the five production-weighted regional aggregates for Sub-Saharan Africa with two non-African reference countries, selected as important world producers of each commodity.

4.2.1 Cotton

Figure 8 completes the cotton partial productivity ratios picture. Looking across regions, the 1980s were uniformly positive. Factor productivity gains were relatively greater in East Africa and the Sahel. For cotton production in East and Southern Africa, the gains of the 1980s represent dramatic reversals of the downward productivity trend of the 1970s; for West Africa,


log Y/A
Figure 8
REGIONAL PARTIAL PRODUCTIVITY RATIOS
COTTON
1968 → 1978 → 1988
MEXICO
PAKISTAN
SAHEL
SOUTH
WEST
CENTRAL
EAST
log Y/L


log Y/A
Figure 9
REGIONAL PARTIAL PRODUCTIVITY RATIOS
COFFEE
1968 → 1978 → 1988
INDONESIA
EAST
BRAZIL
SOUTH
CENTRAL
WEST
log Y/L

the 1980s brought a reversal of previous declines in average labor productivity and continued yield gains.

It is also interesting to compare the relative positions of the SSA regions. For example, cotton factor productivity levels in the Sahel are significantly higher than for other regions, though in the 1980s, Central Africa caught up with the Sahel in terms of labor productivity. Each region experienced yield increases in the 1980s, though these gains still left the four other regions at lower yield levels than that at which the Sahel began its gains in 1968. East Africa began as the least productive cotton region in 1968 and lost ground during the 1970s; yet, that region's significant gains in cotton yields in the 1980s brought it to a level comparable to West, Central and Southern Africa, and beyond the latter in average cotton labor productivity.

Comparing the SSA regions with reference countries provides a useful context for this analysis. The reference countries for cotton—Mexico and Pakistan—followed symmetrically opposite paths from one another. For Pakistan, the significant productivity gains came in the 1980s, when technological innovations (principally new varieties) contributed to dramatic yield increases; yet, those gains followed a decade of nearly stagnant yields and falling labor productivity. The magnitudes of change for Mexico were smaller than those for Pakistan, and the pattern was reversed. Mexico's cotton productivity gains (primarily yield) came in the 1970s, with yield stagnating and labor productivity declining slightly in the 1980s.

Compared with the African aggregates, Mexico operates at a much higher level of factor productivity for both land and labor. Yet, Mexico's cotton productivity stagnated during a decade when Africa made significant gains. The Pakistani pattern is more similar to that of Africa, with declines in average labor productivity in the 1970s followed by significant yield increases in the 1980s.

4.2.2 Coffee

Agricultural factor productivity in Africa looks considerably worse for coffee, the other export crop examined. Indeed, one of the reasons for disaggregating by commodity in this analysis was to observe whether cash crops behaved similarly to food crops. Figure 9 indicates that there was little similarity even between alternative cash crops.

With the exception of East Africa, coffee productivity has suffered during the past two decades on a continent-wide basis. Factor productivity in Southern African coffee fared worst. Substantial and equiproportionate declines in land and labor productivity in the 1970s gave way to relatively greater declines in labor productivity in the 1980s. In West African coffee production, land and labor productivity deteriorated at roughly equal pace throughout both periods.

Coffee factor productivity trends in East and Central Africa were less bleak, though positive changes were small in magnitude. Central Africa saw declining coffee yields reversed in the 1980s, though the region's coffee labor productivity fell slowly but steadily during both

decades. In terms of factor productivity in coffee, Sub-Saharan Africa's only success story was East Africa. While labor productivity in that region was nearly constant during the 1970s and 1980s, yields rose steadily during both decades. East Africa also led the continent in its level of coffee yields, though it attained only the approximate Sub-Saharan average of labor productivity.

In contrast, Brazil begins the first period at a substantially greater level of average labor productivity than any African region, and improved significantly along that axis over both periods.[22] Coffee yields in Brazil, however increased only slightly and were not much different from the East African level by 1988. Coffee productivity in Indonesia, on the other hand was largely stagnant during both periods, with slight deterioration primarily in yield. From this perspective, Indonesia fits well within the African patterns.

4.2.3 Maize

Regarding average factor productivity in maize, the five regions of Sub-Saharan Africa are tightly grouped in terms of levels, though the paths vary across regions. The magnitudes of productivity change are quite similar across regions and periods for maize.

Figure 10 shows maize factor productivity levels in the Southern, Central, and Sahel regions converging from three different directions in the 1980s. West Africa was headed towards that convergence in the 1970s, but changed course positively in the 1980s. As in the case of coffee, East Africa performs best, with improved yields in both decades, and a reversal of average labor productivity declines in the 1980s. Yields improved during the 1980s everywhere but Southern Africa, which shared a roughly equal decline in average labor productivity with Central Africa in that decade.

The reference countries for maize—Thailand and Mexico—both performed at substantially higher levels of average land and labor productivity than any of the SSA regions. Mexico's pattern of consistent yield gains (greater in the 1970s) with little improvement in labor productivity is similar to the Sahel experience, though the starting levels between the two areas were quite different (proportionately much greater in labor productivity). Thailand, too, followed a pattern that would have been plausible in the African context, though, like Mexico, Thailand's changes occurred at significantly higher levels of both land and labor productivity than occurred in Africa.

4.2.4 Rice

The African experience in rice factor productivity is more positive, particularly in the 1980s. As Figure 11 indicates, there was little change in either land or labor productivity for

[22] One should note however, that in contrast to Sub-Saharan Africa, coffee production in Brazil is highly mechanized.

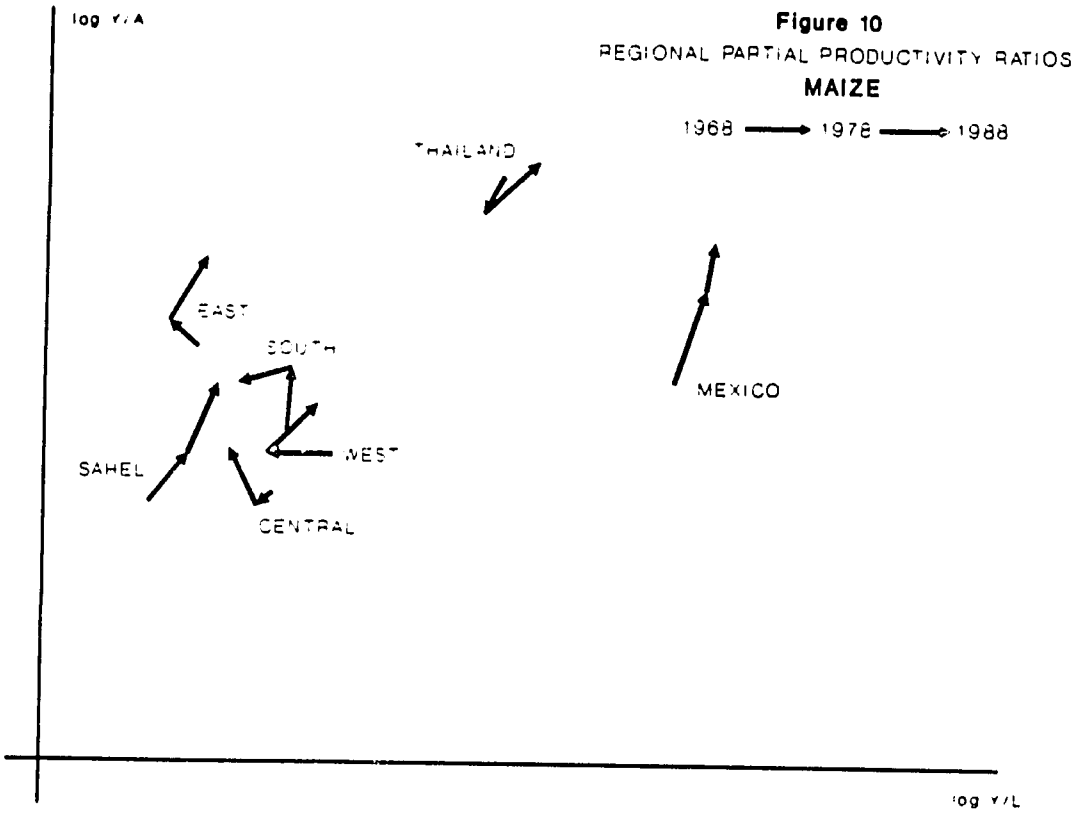


Figure 10

REGIONAL PARTIAL PRODUCTIVITY RATIOS

MAIZE

1968 ⟶ 1978 ⟶ 1988

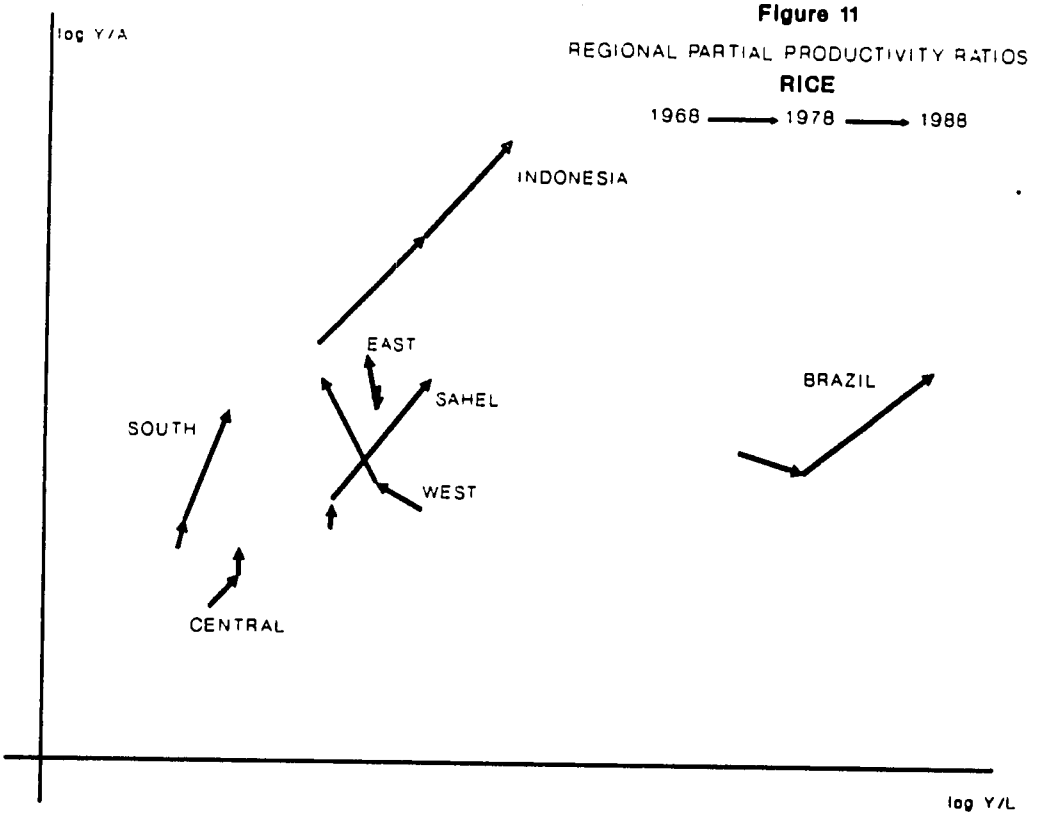


Figure 11

REGIONAL PARTIAL PRODUCTIVITY RATIOS

RICE

1968 ⟶ 1978 ⟶ 1988

any region during the 1970s. All regions but East had slight improvements in yield with little change in labor productivity except for the decline in West Africa. Three of the five regions, however, experienced significant acceleration of yield growth during the 1980s, while the 1970s stagnation in productivity tended to persist through the 1980s for maize in Central and East Africa.

It is also notable that West (and to a slighter extent, East) Africa's yield gain in the 1980s coincided with a decline in average labor productivity. This implies a significant decrease in cultivated area per worker (particularly in the West). West, East, and the Sahel are close to one another in terms of productivity levels, while Southern and Central Africa were relatively deficient in rice labor productivity.

In 1968, Indonesia's rice labor productivity was at roughly the African average, though its yields were significantly greater than all but East Africa's at that time. Yet, factor productivity in Indonesian rice grew explosively over the subsequent twenty years in terms of both land and labor. Brazil, too, provides an interesting contrast. While the relative superiority of Indonesia's rice productivity performance was primarily in yield, Brazil's gains were almost exclusively derived from increased labor productivity. In fact, this difference nicely illustrates Hayami and Ruttan's induced innovation model, in which one would expect the relatively land-rich and labor-scarce Brazil to pursue labor-saving technical change (and vice versa for Indonesia).

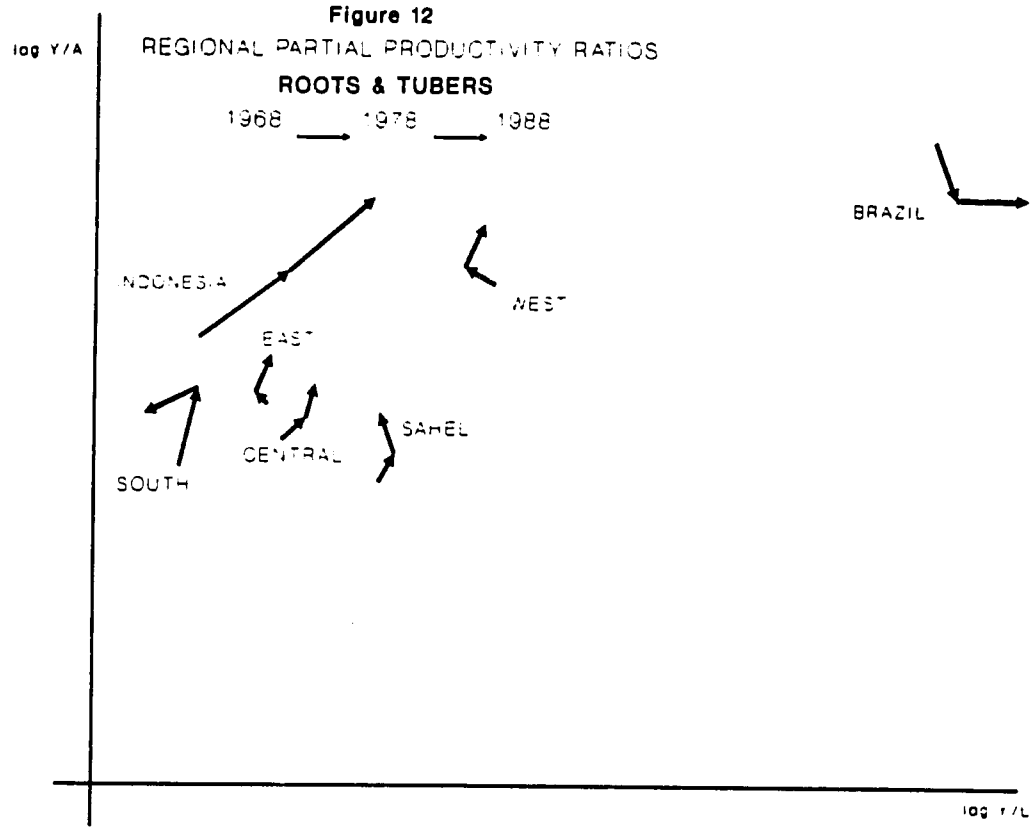
4.2.5 Roots and Tubers

For roots and tubers, Figure 12 reflects little productivity change anywhere in Africa. Yields improved slightly (with the exception of Southern Africa in the 1980s), while labor productivity barely changed (again, with the negative exception of Southern Africa in the second period). Yield levels were quite similar in each of the SSA regions expect West Africa, where yields were somewhat greater.

As in the case of rice, Indonesia starts the first period at African levels, but makes significant gains along both axes in both periods. Also as in the rice example, Brazil starts at a much higher level of labor productivity and increases from there. Brazil, however, was the only case in which yields declined during the 1970s.

4.3 General Observations

Considered as a group, Figures 8 through 12 also lend themselves to comparisons of paths and levels across commodities. Have particular regions been consistently more or less productive than other regions? For instance, East Africa by 1988 had attained the highest level of yields in four of the five commodities considered (the exception being cotton). Yet, East Africa in general attained average or below average levels of average labor productivity. Southern Africa, in contrast, achieved the lowest levels of average labor productivity in 1988



in every commodity except maize (and it was the only region to decline in both land and labor productivity in maize during the 1980s).

Figures 8 through 12 also permit comparisons of the productivity path followed by particular regions for different commodities. Southern Africa's path for roots and tubers is virtually identical to its path for maize (both food crops), while its path for cotton is the reverse. Indeed, West and East Africa also followed similar paths in maize as they did in roots and tubers. Similarly, Central Africa's paths for roots and tubers and rice are virtually identical, as are its paths for maize and coffee. In this case, the pattern vis-a-vis food versus cash crops is less clear.

None of the regions follow the same path for coffee as they do for cotton, suggesting a lack of clear linkages between productivity in export crops. Average labor productivity fell in West Africa for every commodity in the 1970s, though that trend continued only for coffee and rice during the 1980s. In contrast, the Sahel was the only region in which yields increased in all commodities in both periods (though in some instances the increases were quite small).[23]

Finally, Figures 8 through 12 permit several broad generalizations about productivity trends. The most pertinent generalization is that average land and labor productivity change in

[23] Note that coffee is not grown in the Sahel.

Sub-Saharan Africa was significantly more positive in the 1980s than in the 1970s. During the first period, food crop productivity tended to grow, but the magnitudes of change were quite small. Cash crop productivity during the 1970s was more negative. Yet, with the sole exceptions of coffee in Southern and West Africa, and maize in Southern Africa, factor productivity in the 1980s grew positively for all regions and commodities.

The experience with regard to average labor productivity in the 1980s was more mixed and movements tended to be small in both directions. Thus, one can also generalize that *factor productivity gains, most of which occurred during the 1980s, tended to derive primarily from increases in yields rather than from growth in labor productivity.*

The agricultural value added-based productivity measures presented in Figures 6 and 7 tell a somewhat different story. Measuring agricultural output by agricultural value added (in dollars) incorporates the entire agricultural sector (rather than just the five commodities examined in Section 4.1), and measures the effects of nominal exchange rate movements along with technical change. The combination of these effects creates a much more negative picture of productivity change in the 1980s. Measured in these terms, the fragile productivity gains of the 1970s are negated by losses in the 1980s.

The following chapter presents the results of statistical measures of productivity change.

5. TOTAL FACTOR PRODUCTIVITY CHANGE IN AFRICAN AGRICULTURE

This chapter presents the results of an alternative type of productivity measurement known as total factor productivity (TFP). In contrast to the partial productivity measures described above, TFP measures do not distinguish the individual productivity contributions of specific factors of production. Rather, TFP measurements describe the combined change in the productivity of all factors together. While partial productivity measures have the advantage of identifying the specific factors, TFP has the advantage of controlling for changes in the levels of inputs applied.

5.1 Technical Background

Since Solow (1957), total factor productivity growth has been measured as the residual growth in output not explained by increases in the levels of inputs. In general, this increase in productivity is attributed to a constant rate of technical change. Yet, as Griliches long ago asserted, "...it does not further our understanding of growth to label the unexplained residual changes in output as 'technical change.' Nor does it help much to measure these changes accurately if we do not know what they are."[24] Data limitations in the African context prevent this chapter from fully addressing Griliches' criticism.

The methodology for measuring TFP change adopted in this study requires the econometric estimation of commodity-specific production functions. The limited number of observations available and the quality of the data in regressions on aggregate data where the units of observation are countries suggests that the simplest specification for the production functions is the most appropriate. The estimates presented in this chapter are thus specified as Cobb-Douglas functions (and estimated in log-linear form).[25]

This study adopts the general notion that technical change proceeds at a constant rate over time and is disembodied. That is, technical change does not reside in particular new vintages of machinery, but rather, is a generalized increase in the efficiency with which producers

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[24] Griliches (1963), p. 331-2

[25] Some studies, most notably Lau and Yotopoulos (1989), adopt the translog form for estimating cross-country production functions. The primary advantage of that approach is that it imposes fewer restrictions on the elasticities of substitution across factors of production, whereas the Cobb-Douglas form imposes a unitary elasticity of substitution. In principle, eliminating such restrictions is attractive; however, in practice, the loss of degrees of freedom imposed by the number of higher-order terms in a fully specified translog production function is prohibitive in a small data set. In addition, the poor quality of the aggregate African agricultural data leaves one with little confidence in the validity of second order terms in the production function. Moreover, Hayami and Ruttan (1985) failed to reject the null hypothesis of a unitary elasticity of substitution, thus suggesting that Cobb-Douglas is a reasonable functional form for the present purposes.

combine inputs. As such, technical change is realized through a shift in the entire production function over time.

The present analysis further assumes that technical change is "Hicks neutral" (i.e., that marginal rates of substitution remain constant and that factor proportions remain constant, given constant relative factor prices). That is, neutral technical change "saves" neither labor nor capital relative to one another as output increases. Thus, estimated shifts in the production function can be thought of as "parallel" upward movements of the production function (or parallel shifts towards the origin of the relevant isoquants).

Figure 13 illustrates this concept. The production function relates the quantity produced (Y) to the level of input use (X). One may estimate a production function for a given commodity at a time 1 as in Figure 13. For present purposes, this production function is based on a cross-section of countries at time 1. By constructing the data set to include a second cross-section of the same countries at a second point in time, one can measure the *shift* (if any) for that production function between time 1 and time 2. Total factor productivity change is inferred from the change in the intercept of the production function from time 1 to time 2. The dashed lines in Figure 13 show that for the same quantity of inputs in both periods ($X_{1,2}$), a greater quantity of output is realized at time 2. The percentage difference between Y_1 and Y_2 is equivalent to the percentage change in the intercept.

The production functions account for all inputs used. The growth in TFP is taken to be the increase in output *not* accounted for by increased input use. That is,

$$\% \Delta\ TFP = \% \Delta\ output - \% \Delta inputs \qquad (4)$$

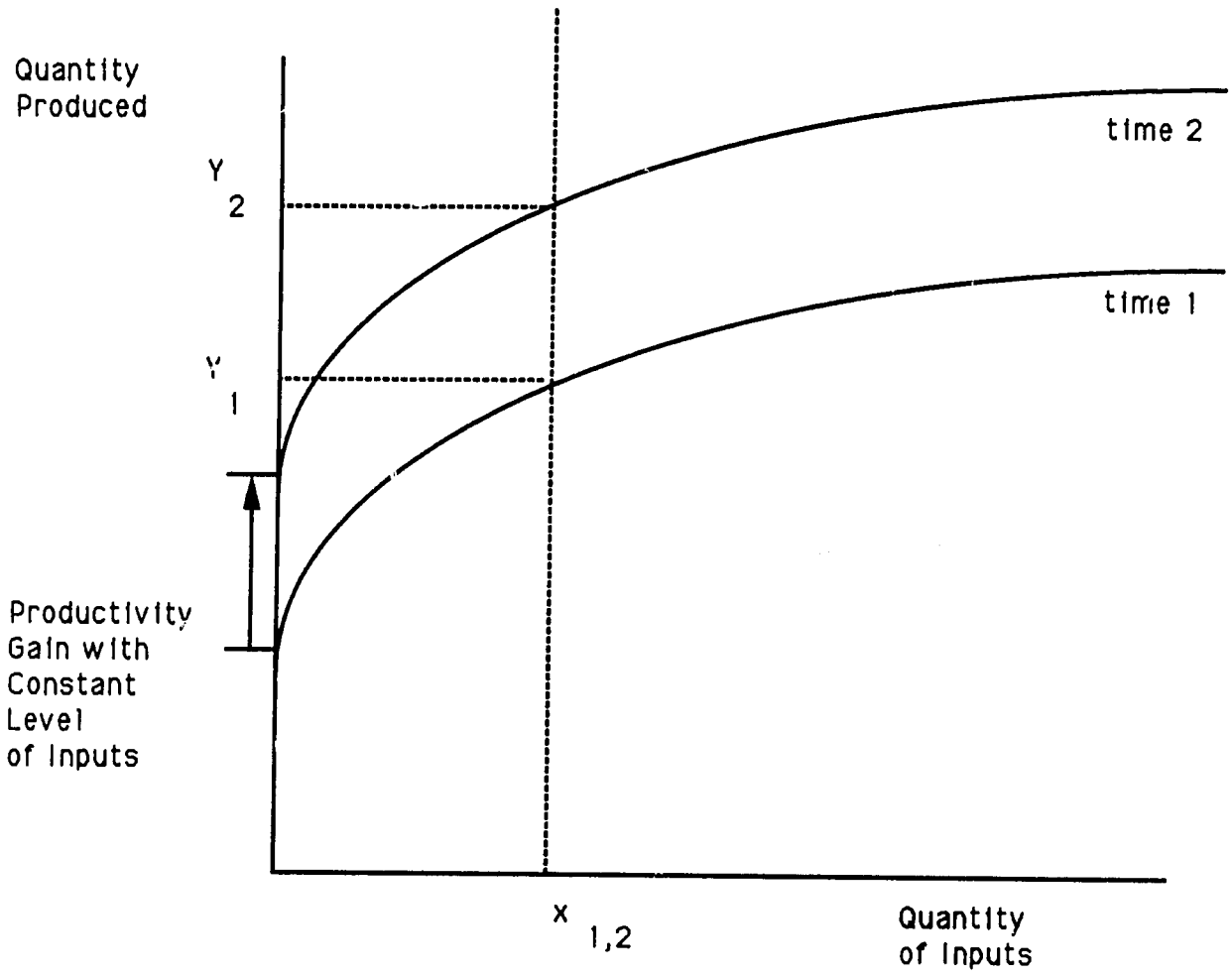
Thus, if over a given interval of time, one observes a 10 percent production increase accompanied by a 7 percent increase in the use of inputs, that would imply that there had been a 3 percent increase in the productivity of those resources. The notion of time-shifting production functions and TFP growth is derived with greater rigor in Appendix D.

5.2 Production Function Results and TFP Change

The production function estimates reported in this section result from a Cobb-Douglas specification of the general production function

$$Y_j = f(L_j, A_j, F, t) \qquad (5)$$

Figure 13: Productivity Change in Production Functions



That is, output of commodity j is a function of labor applied to j (L_j), area harvested for j (A_j), total fertilizer application (F), and time (t).[26]

The panel data used to estimate this function consists of a cross-section of the n countries that produce commodity j, observed at three separate times—1968, 1978, and 1988 (with variables for each year calculated as the three-year average levels surrounding that year to reduce noise). This permits the estimation of neutral shifts in the production function over time with the use of dummy variables for the two later time observations. Statistically significant estimates of these time dummies would imply different intercepts for the function in those periods.

In addition to permitting the identification of technical change, the use of panel data allows one to control for unobserved differences between countries (or observable but unaccounted for differences) that are constant over time. To the extent that these inter-country differences are correlated with factor intensity or productivity changes in the countries, not controlling for those differences can result in left-out variable bias in the coefficient estimates.

One econometric technique available to control for these country-specific effects is known as the "random effects model." This technique accounts for country-specific effects by making the assumption that those effects cause systematic shifts in the intercepts of the production functions (and thus appear in the error term). Random effects estimation accounts for this by combining the results of estimating the production function two ways: across countries' mean levels over time, and within countries based on the difference from their means at different points in time.[27]

Adopting a random effects estimation procedure, the specific equation used to measure SSA-wide productivity change for a given commodity j in country i is

$$y_{jit} = \beta_0 + \beta_1 l_{jit} + \beta_2 a_{jit} + \beta_3 f_{it} + \beta_4 T78 + \beta_5 T88 + (\mu_{ji} + \varepsilon_{jit}) \qquad (6)$$

[26] Fertilizer is measured in quantities of chemical fertilizer. In these estimations, fertilizer is not disaggregated by commodity. This is justified to the extent that African farmers practice inter-cropping. As noted above, application of chemical fertilizer are quite low, and reported as zero in several countries. To reflect the fact that some natural fertilizers are probably applied, and for the fact that there exists some degree of natural soil fertility, we have added a constant 10,000 MT to the fertilizer quantity for each country (based on the discussion in Timmer (1986).

[27] See, for example, Judge, et.al. (1980)

where lower case letters refer to natural logs, μ_{ji} is the country-specific error component, and ε_{jit} is the time-varying error for the production of commodity j in country i.[28] T78 and T88 are dummy variables, allowing the production function's position to shift up or down over time. The magnitude of these shifts provides a measure of TFP change. The full set of estimated regression coefficients and relevant statistical tests are presented in Appendix E.

Table 3 summarizes the results of these regressions as they pertain to total factor productivity change. The first row in Table 3 describes the percent change in total factor productivity for each commodity for the entire decade from 1968 to 1978. The second row describes the rate of TFP change for the subsequent decade; and, the bottom row of Table 3 describes the average annual rate of TFP change over the entire 20 year period from 1968 to 1988. Figure 14 depicts these results graphically.

TABLE 3 Rates of TFP Change, Africa-wide 1968-88

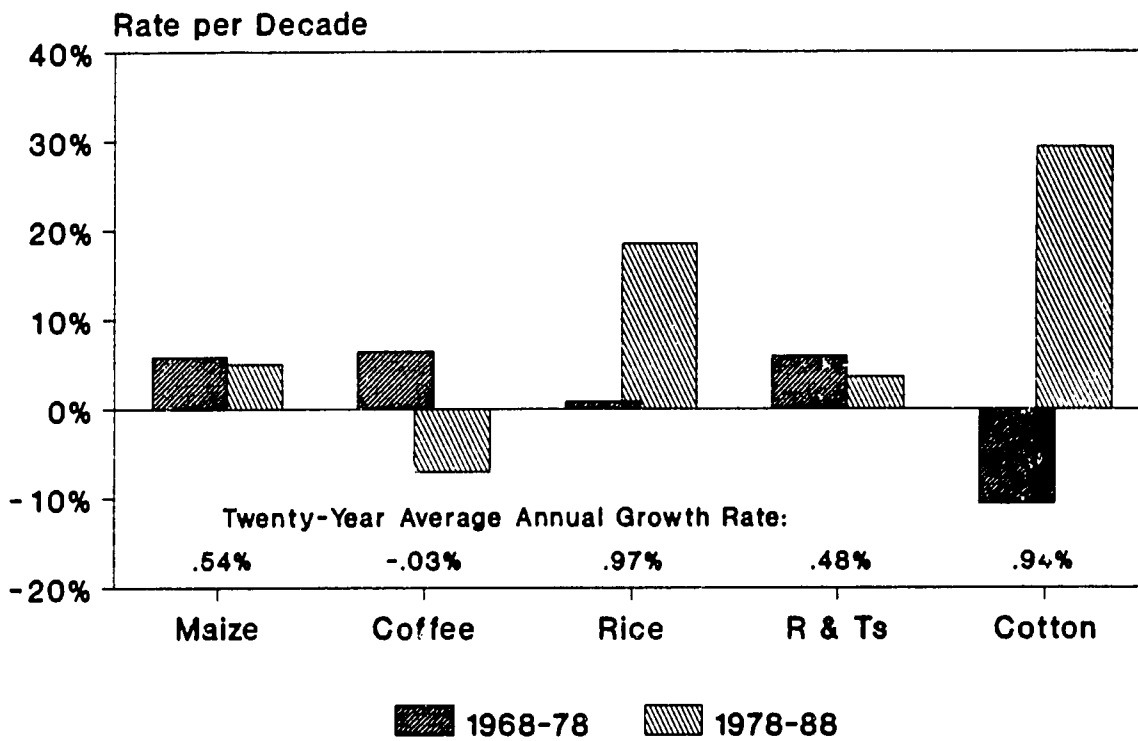
Period	Coffee	Cotton	Maize	Rice	Rts & Tbs
Total % Change 1968-78	6.4	-10.6	5.8	0.8	5.9
Total % Change 1978-88	-7.0	29.3	5.0	18.5	3.6
Avg. Annual Change 1968-88	-.03	.94	.54	.97	.48

Looking across commodities from 1968 to 1978, one sees positive growth in total factor productivity in each of the commodities except cotton, which suffered a 10.6 percent productivity loss. This implies that the rate of increase in cotton inputs exceeded the rate of increase in cotton output by over 10 percent, thus reflecting that rate of productivity loss over the decade.

[28] The random effects structure assumes that both components of the error equal zero on average ($E(u_{ji}) = E(\varepsilon_{jit}) = 0$), and that the country-specific error component is uncorrelated with the random error ($E(u_{ji}\,\varepsilon_{jit}) = 0$). This model also assumes that the errors are exogenous, and therefore uncorrelated with the regressors, e.g., $E(u_{ji}\,x_{jit}) = E(\varepsilon_{jit}\,x_{jit}) = 0$, where x is a list of inputs.

Figure 14

TFP Growth in Sub-Saharan Africa



In contrast, total factor productivity for coffee and maize each grew by approximately six percent over the course of the decade. Productivity in rice and roots and tubers also grew positively, though more slowly.

For each of these commodities except maize, productivity change looked quite different in the 1980s than it did in the 1970s. For coffee and cotton, the 1980s brought dramatic reversals of the productivity trends of the previous decade. Coffee's productivity gains in the 1970s were completely reversed in the 1980s, leaving the *level* of coffee productivity continent-wide roughly where it had been in 1968. In contrast, cotton productivity increased by nearly 30 percent during the 1980s, more than making up for the productivity losses of the 1970s. It is interesting to note the stark differences in productivity trends for the two export crops examined. This result parallels the findings on partial productivity ratios presented in Chapter 4.

Productivity growth in the food crops (maize, rice, and roots and tubers) remained positive in both decades. The rates of growth, however, declined over time for maize and roots and tubers. Conversely, rice productivity trends resembled those of cotton, sharply increasing during the 1980s.

Including time/region interaction terms in the production functions extends the analysis of productivity change to the same level of regional disaggregation examined above for the partial productivity ratios. Whereas the previous regression permitted the production function for a given commodity to shift for the entire continent, the disaggregated analysis allows each region of SSA to have its own production function in each of the three periods. This permits comparisons of productivity trends both across regions for a given commodity and across commodities for a given region.

The expanded production function for commodity j, specified as an OLS regression, takes the form

$$y_{jit} = \beta_0 + \beta_1 l_{jit} + \beta_2 a_{jit} + \beta_3 f_{it} + \sum_{r=1}^{m-1} \sum_{t=1}^{T} \beta_{rt}(region_r * time_t) + \sum_{t=2}^{T} \beta_t(region_M * time_t) + \varepsilon_{jit}; \quad m = regions\ 1...5,\ t = 1...3 \tag{7}$$

That is, in place of the two time dummies in equation (6), equation (7) substitutes time/region interaction terms for each region in each of three years (except for one excluded region/year, Sahel*T68).

The results of immediate interest pertain to the changes over time, if any, in the intercepts of the production functions for given regions. In this specification, one calculates shifts in the production function associated with a given region as the difference between the coefficients for the periods of interest. (The levels of the coefficients directly estimated in

equation (7) refer to the difference between the given region/time and the Sahel in 1968.) Thus, in terms of equation (7), the shift from one period to the next would be $\beta_{rt} - \beta_{rt-1}$.

Implementing this model for the five commodities and five regions results in a highly disaggregated picture of TFP change. Yet, tests of statistical significance suggest that we must regard the results of that analysis as tentative. Most of the region/commodity-specific productivity changes are found not to be statistically significant. While this result is interesting in itself, its interpretation is not clear, since it results from some combination of limited technical change, a small sample size, and substantial heterogeneity within regions. As a result of this ambiguity, the findings of the disaggregated TFP analysis have been relegated to Appendix E.

5.3 General Observations

Returning to Figure 14 permits several broad generalizations regarding continent-wide TFP trends across commodities. During the 1980s, TFP growth continent-wide was positive in four of the five commodities examined in this study, the sole exception being coffee. Comparing the 1970s to the 1980s, however, one finds that TFP in three of the commodities—maize, coffee, and roots and tubers—grew more slowly than during the previous decade.

In terms of annual average rates of TFP growth from 1968 to 1988, coffee, again, is the only commodity to suffer productivity losses. TFP in rice and cotton each grew by just under 1 percent per year on average over the two decades. Maize and roots and tubers experienced average annual TFP growth of approximately half that rate, while average coffee TFP change was just slightly negative over the period.

A TFP increase of 1 percent per year is by no means negligible. It contributes to growth in the total output of those commodities 1 percent beyond the increase in the quantity of inputs allocated. These findings, then, justify guarded optimism regarding Africa's progress towards the first phase of agricultural transformation. African agriculture, as represented by maize, rice, coffee, cotton, and roots and tubers, has become more productive over time. Total factor productivity in rice and cotton in particular increased rapidly between 1978 and 1988.

In quite general terms, agricultural productivity during the 1980s was more positive than during the 1970s. Of the 24 region/commodity combinations measured in both decades (see Appendix E), 12 registered productivity increases during the 1970s. During the subsequent decade, 17 of the region/commodity combinations registered productivity gains. This crude indicator says nothing about the magnitudes of change; yet, it is broadly indicative of greater progress in the latter decade.

Nonetheless, there remain several causes for concern. Productivity growth in African agriculture has been uneven, both across commodities and across regions. East Africa has performed relatively well, while West and Southern African agricultural productivity growth has been less promising. Moreover, the instances of productivity gain seen in many regions and

commodities during the 1980s were necessary simply to compensate for widespread productivity *losses* during the 1970s.

Roots and tubers remain important subsistence crops for many in Sub-Saharan Africa. The results presented here, however, tend to reflect relatively little technical change for those crops. TFP growth was positive for roots and tubers, but the rate of TFP growth was quite slow in most instances, and slower during the 1980s in three of five regions. This suggests a need for increased attention to roots and tubers among agricultural researchers and funding institutions.

An additional cause for concern arises from looking "behind" these *total* factor productivity results by recalling the specific trends in land and labor productivity revealed in the partial productivity ratios presented in Chapter 4. Those findings indicated that, by far, most of the productivity gains resulted from *yield* increases. Labor productivity has been largely stagnant. The greatest gains in labor productivity tended to be in cotton production; yet, there, too, greater gains came in yields. In the other commodities examined, changes in labor productivity were negligible (except for the labor productivity losses suffered in coffee in Southern and West Africa).

In general, however, positive movements in the labor productivity ratios were in a direction characterized by output growth rates roughly equal to population growth rates. Increased labor inputs and land-saving technical change resulted in greater yields with little change in labor productivity.

This is particularly troubling vis-a-vis AID's concern for "people-level impacts." In Sub-Saharan Africa, people-level impacts must largely address the welfare of agricultural laborers. For them, there can be no sustainable welfare gains without technical change to increase average labor productivity. To date, no such change has occurred.

6. CONCLUSIONS AND IMPLICATIONS FOR FUTURE RESEARCH

This study presents an empirical basis for assessing Sub-Saharan Africa's progress towards agricultural transformation. As noted in Chapter 1, the agricultural transformation typically evolves through several identifiable phases. The spark in this sequence is an increase in agricultural productivity, which ultimately leads to the progressive integration of agriculture into the macroeconomy. These are the ingredients which permit the inter-sectoral resource flows underlying economic growth.

Agricultural transformation has been intrinsic to the growth process of most countries. By extension, it follows that agricultural productivity plays a key role in promoting the early stages of economic growth. The present "progress report" on agricultural transformation in Africa provides a step towards understanding the role of agricultural productivity in the economic growth process in Africa.

This progress report is based on empirical measures of both agricultural productivity trends and the extent to which African countries have succeeded in integrating agriculture into their macroeconomies. The general finding with regard to agricultural productivity trends is one of guarded optimism. There is clear evidence of productivity growth in African agriculture. The rates of growth were somewhat more robust in the 1980s than in the previous decade, though that progress has been uneven both across regions and commodities. For instance, the analysis in Appendix E suggests that productivity growth across all commodities tended to be most robust in East Africa, while productivity change in West and Southern Africa has been less promising. There were also substantial differences in productivity growth across the commodities examined. Coffee productivity, for example, grew more slowly in every region over time, and productivity growth was negative on average from 1968 to 1988 in two of four coffee-growing regions. In contrast, cotton and rice productivity tended to increase strongly during the 1980s over the 1970s.

It is also informative to look at the productivity performance of particular regions in distinct time periods as opposed to the 20 year average productivity growth. In terms of the average, maize and roots and tubers look similar. Yet, those averages conceal the fact that the roots and tubers productivity growth averages are relatively low because most of the regions experienced consistently slow growth in productivity in those crops. In contrast, the 20 year average productivity growth for maize, though only slightly greater than that for roots and tubers conceals much greater inter-regional variation. In general, however, these findings suggest that Sub-Saharan Africa is progressing into the first phase of agricultural transformation.

This progress is yet to become apparent in agriculture's contribution to economic growth. This study has found that agriculture's contribution to economic growth in Sub-Saharan Africa has diminished dramatically during the past twenty-five years. Indeed, for a sub-sample of countries, agriculture actually impeded economic growth during the early and mid-1980s.

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One might add that the growth accounting exercise presented in Chapter 2 indicates that Africa has nowhere to turn except to agriculture as a source of economic growth. It would thus be a serious mistake for donors to abandon African agriculture. Indeed, the results of Chapter 2 suggest that donors should concentrate strongly on interventions to promote agricultural productivity as a means of promoting general economic growth in Sub-Saharan agriculture.

In reviewing the potential implications of these results, Peter Timmer has recently suggested that

> If growth in agriculture contributes not just to higher living standards of rural people but also stimulates growth in productivity for the entire economy, governments must take an entirely new view of the role of agriculture in the development process. Especially in the early stages of development when the agricultural sector remains large in macroeconomic terms, stimulating its growth seems likely to have very large economy-wide effects.[29]

The present study provides a firm basis for pursuing these implications. *This empirical investigation of Africa's progress in agricultural transformation is the first step towards developing a fuller understanding of the role of agricultural productivity in promoting general economic growth in Africa.*

The agricultural productivity measurements presented in this study provide the analytical and empirical foundation necessary for developing a model to investigate the economic growth implications of agricultural productivity change in Africa. Such a model would need to capture the effects of inter-sectoral resource transfers intrinsic to agricultural transformation, as well as the forward and backward linkages between agriculture and industry that sustain the growth process.

A preliminary step in this modelling exercise would be to gain a deeper understanding of the determinants of agricultural productivity change in Africa. In practice, such an understanding would need to address a specific policy context, and hence might initially be developed with a particular country in mind. In practice, a growth model would need to be country-specific in order to capture the productivity and growth implications of a particular policy and physical environment. These productivity determinants could then be incorporated into a growth model as exogenous variables and used to simulate growth effects.

One appropriate modelling strategy would be to develop a system of empirically-based simultaneous equations that simulate the growth of sectoral output. The sum of the sectoral outputs would determine aggregate economic growth. The advantage of estimating such a system simultaneously is that it permits the growth of each sector (i.e., agriculture and non-agriculture) to be mutually dependent. This feature addresses inter-sectoral resource allocation

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[29] Timmer (1991), forthcoming.

made possible by agricultural productivity growth, and allows for the possibility that increased agricultural productivity increases productivity in the general economy. The empirical measures of productivity growth presented above could guide the simulations to be performed with such a model. Such simulations could demonstrate the general growth effects of changes in agricultural productivity.

Developing a model for a particular country might also permit access to more detailed data, thus avoiding some of the data problems inherent in the present analysis. It would also be interesting to integrate these findings with more micro-data based analyses of African agricultural productivity currently being sponsored by the Africa Bureau.

APPENDIX A

DATA SOURCES AND ISSUES

DATA SOURCES AND ISSUES

The productivity measurements presented in Chapters 3 and 4 are based on a series of panel data set constructed from data published in the FAO's *Production Yearbook* series. Each of the five commodities analyzed required its own data set, since not all of the countries produce all of the commodities. The panels consist of the largest cross-section of countries possible in which all observations were available for each of three time periods. Such data sets are known as "balanced panels."

The time observations are separated by 10 years. Thus, the cross-sections are repeated for 1968, 1978, and 1988. For each year, the actual data points are the averages of the surrounding three years. This average is intended to reduce some of the noise in the data.

The variables required for the analyses included: total output for each commodity (Y_i), area harvested for each commodity (A_i), total fertilizer consumed in the country (F), and total labor used on each commodity (L_i).

The published FAO data provided data for output and area for each crop, along with total fertilizer consumption in the country (excluding manure) and various aggregates of area, including total permanent crop land. The latter two variables required several assumptions for inclusion in the analyses.

Several countries, for example, reported zero fertilizer consumption. While it may be true that little fertilizer was consumed in those countries, it is highly unlikely that the true quantity was zero. Moreover, these data include only chemical fertilizers and ignore the natural fertility of the soil.

Timmer (1986) develops a rationale for adjusting fertilizer quantities when estimating production functions. In accordance with that approach, as well as some experimentation for goodness of fit, the fertilizer quantities for each country were adjusted upward by a fixed amount of 10,000 metric tons.

The derivation of crop-specific labor allocation was more problematic. The analysis required crop-specific labor (L_i); yet, FAO supplied only total agricultural labor (L). The limited other information available included crop-specific land allocations (A_i) and total arable and permanent crop land (A). Given this information, the only practical solution was to impose the assumption that labor was allocated across commodities in proportion to land. That is,

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$$L_i = \frac{A_i}{A} \times L \tag{A.1}$$

This assumption is problematic in that it ignores the relative labor intensity of alternative crops, and excludes producers from allocating labor optimally across crops. In addition, in statistical terms, it imposes a significant degree of multicollinearity between (A_i) and (L_i). With regard to the second problem: 1) these factors of production are naturally collinear to some extent anyway, and 2) the fact that total agricultural labor force and crop-specific area shares vary independently prevents $\frac{Y_i}{L_i}$ and $\frac{Y_i}{A_i}$ from being perfectly collinear.

The imposition of a fixed relationship between land and labor allocations implies that producers cannot allocate labor across crops in such a way as to equate the marginal labor productivity on each crop, as economic theory suggests of cost-minimizing producers. While one might question whether such an assumption is even appropriate for agriculture in Sub-Saharan Africa, where market information is often poor and an individual farmer's fields may be quite distant from one another, statistical tests further suggest that this labor allocation rule is viable.

Specifically, we simultaneously estimated the system of production functions as seemingly unrelated regressions, with the restriction that the marginal rates of productivity be equal across commodities. Given the constant returns to scale Cobb-Douglas production function, $Y_i = cL_i^{\alpha}A_i^{1-\alpha}$, this restriction takes the form $\frac{\alpha_i * P_i * Y_i}{L_i} = \frac{\alpha_j * P_j * Y_j}{L_j}$ for commodities i and j, where P = output price. This restriction was not statistically significant, indicating that the data as constructed did not violate the assumption of equal marginal productivities too flagrantly.

An alternative strategy would have been to use normative labor requirements to allocate the total labor figure provided by FAO.[1] The problem with that approach, however, is that such normative figures (which are rarely available for specific locations) do not vary with relative output prices. Land allocations, however, will vary in this regard, and thus may provide better guidance for labor allocations than would normative labor requirements.

The overall quality and reliability of the FAO data is often criticized. This data is reported to FAO by the governments of each country. Undoubtedly, many of these criticisms are justified. In fact, it is difficult to imagine a more difficult subject on which to collect data than African agriculture. These problems are greatly magnified by the need to have consistent cross-country data on a range of commodities at different points in time. Micro data sets may offer greater internal reliability; yet, they are rarely available in panel form (e.g., for the same

[1] "Normative" data refers to some agronomic notion of how much labor should be allocated to a given crop.

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households at different points in time), and present problems of generalizability to the countries where they are gathered. In the next phase of this research, I hope to work with several micro data sets and attempt to reconcile them with the results from macro data.

In the short run, however, there is no substitute for data such as is published by the FAO for the type of analysis undertaken in this report. The best one can do is to undertake the analysis with explicit recognition of these problems and to interpret the results accordingly.

APPENDIX B

REGIONAL DIVISION OF COUNTRIES

REGIONAL DIVISION OF COUNTRIES

The regional aggregation of countries into five groups is taken from the FAO's 1986 study, *African Agriculture: the Next 25 Years*. Countries are assigned to regions as follows:*

Sudano-Sahel:

Burkina Faso (BKF)
Cape Verde (CVD)
Chad (CHD)
Gambia (GMB)
Mali (MAL)
Mauritania (MAU)
Niger (NIG)
Senegal (SEN)
Somalia (SOM)
Sudan (SUD)

East:

Burundi (BUR)
Ethiopia (ETH)
Kenya (KEN)
Madagascar (MAD)
Mauritius (MRS)
Rwanda (RWD)
Uganda (UGD)

West:

Benin (BEN)
Ghana (GHN)
Guinea (GUN)
Guinea-Bissau (GBS)
Ivory Coast (IVC)
Liberia (LIB)
Nigeria (NGA)
Sierra Leone (SLN)
Togo (TGO)

Southern:

Angola (ANG)
Botswana (BOT)
Lesotho (LSO)
Malawi (MLW)
Mozambique (MZB)
Swaziland (SWZ)
Tanzania (TNZ)
Zambia (ZAM)
Zimbabwe (ZIM)

Central:

Cameroon (CAM)
Central African Republic (CAR)
Congo (CON)
Equatorial Guinea (EQG)
Gabon (GBN)
Zaire (ZRE)

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* The presence of any given country in a particular analysis is subject to data availability.

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APPENDIX C

PARTIAL PRODUCTIVITY RATIOS IN KENYA AND CAMEROON

PARTIAL PRODUCTIVITY RATIOS IN KENYA AND CAMEROON

Kenya and Cameroon

One can also separate out the partial productivity ratios for individual countries. Figures C.1 and C.2 compare the partial productivity ratios for all five commodities for Kenya and Cameroon.

Comparing the paths of the partial productivity ratios for each commodity between these countries, one finds strong contrasts. Indeed, the partial productivity ratios for given commodities tend to move in symmetrically opposite directions in the two countries. For instance, while both yield and labor productivity for cotton fall in Kenya from 1968 to 1978, it rises rapidly in Cameroon. Cotton then recovers along both axes in Kenya, but fall slightly in Cameroon during the next decade.

Similarly, Kenya's coffee productivity increases during the 1970s in the symmetrically opposite direction from the fall in Cameroon's coffee productivity; during the 1980s, Kenya's coffee labor productivity falls while Cameroon's rises. Kenya also lost labor productivity in maize during the 1970s while Cameroon's increased slightly. Both countries increase maize yields during the 1980s, though Kenya's labor productivity remained virtually stagnant while Cameroon benefitted from an increase in maize labor productivity during that period.

The countries also moved in opposite directions with regard to yield and labor productivity in rice, Cameroon, again, moving positively. In the case of roots and tubers, both countries realized slight yield increases in both decades, though Kenya lost labor productivity in both periods and Cameroon realized slight gains.

While Cameroon's transitional paths appear more positive than Kenya's in general, one can also compare the *levels* of yield and labor productivity. Figures C.1 and C.2 are drawn to the same scale. Thus, the position of the arrows relative to the origin reflect levels of productivity. From this perspective, the comparison is more mixed. The relative heights of the arrows indicate relative yields.

For each commodity except cotton, Kenya attained significantly greater yields than did Cameroon. In 1968 and 1978, for example, maize yields in Kenya were over 70 percent greater than they were in Cameroon, though Cameroon's more rapid increase from 1978 to 1988 brought it to within 20 percent of Kenya's level. In coffee, Kenya started with approximately 50 percent greater yields than Cameroon. Kenya's yield advantage in coffee increased to roughly 180 percent in 1978, and narrowed to approximately 125 percent in 1988. While environment and technology may have contributed to these differences, it is also the case that Kenya's coffee export pricing policies were more favorable to producers than those of Cameroon.

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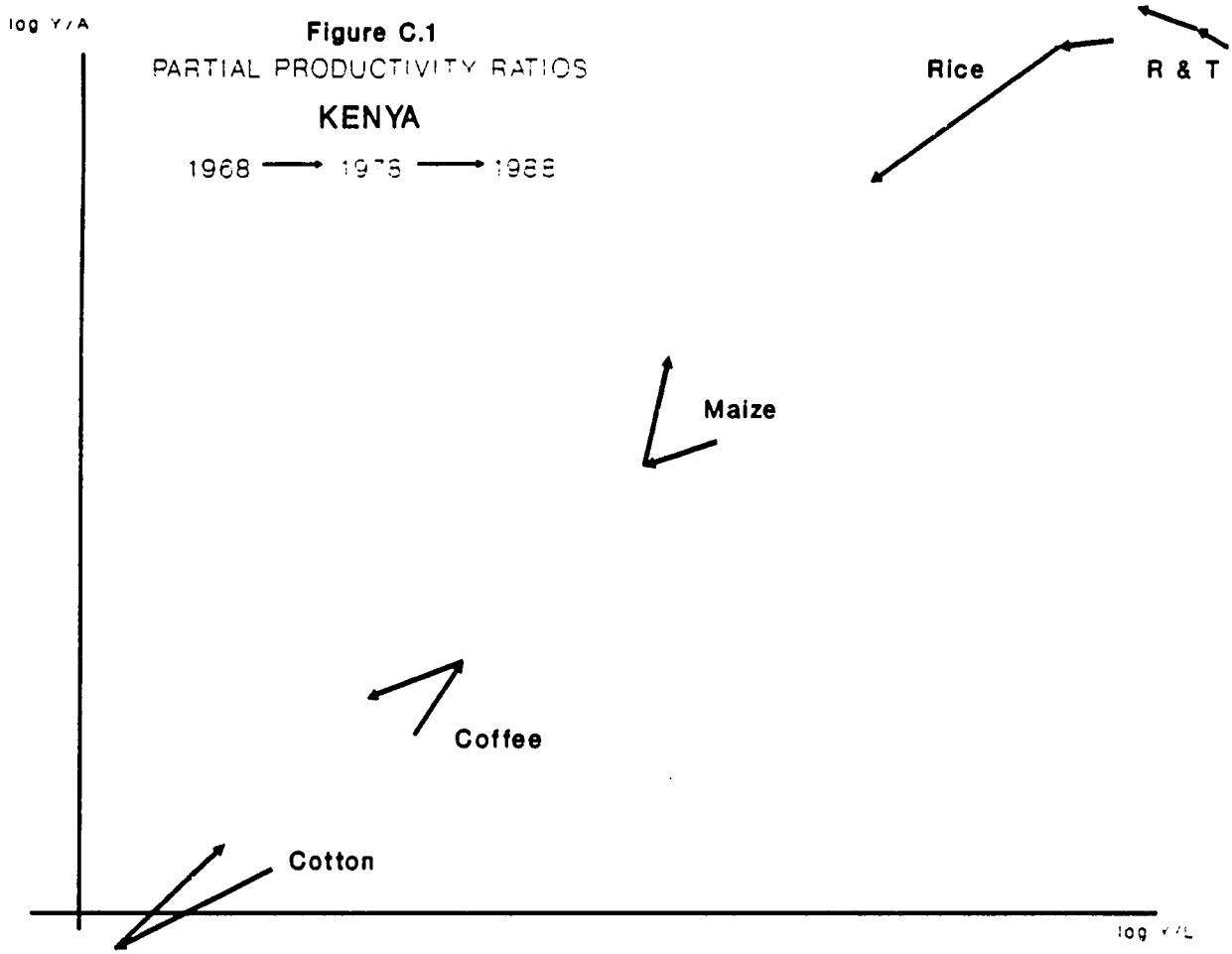
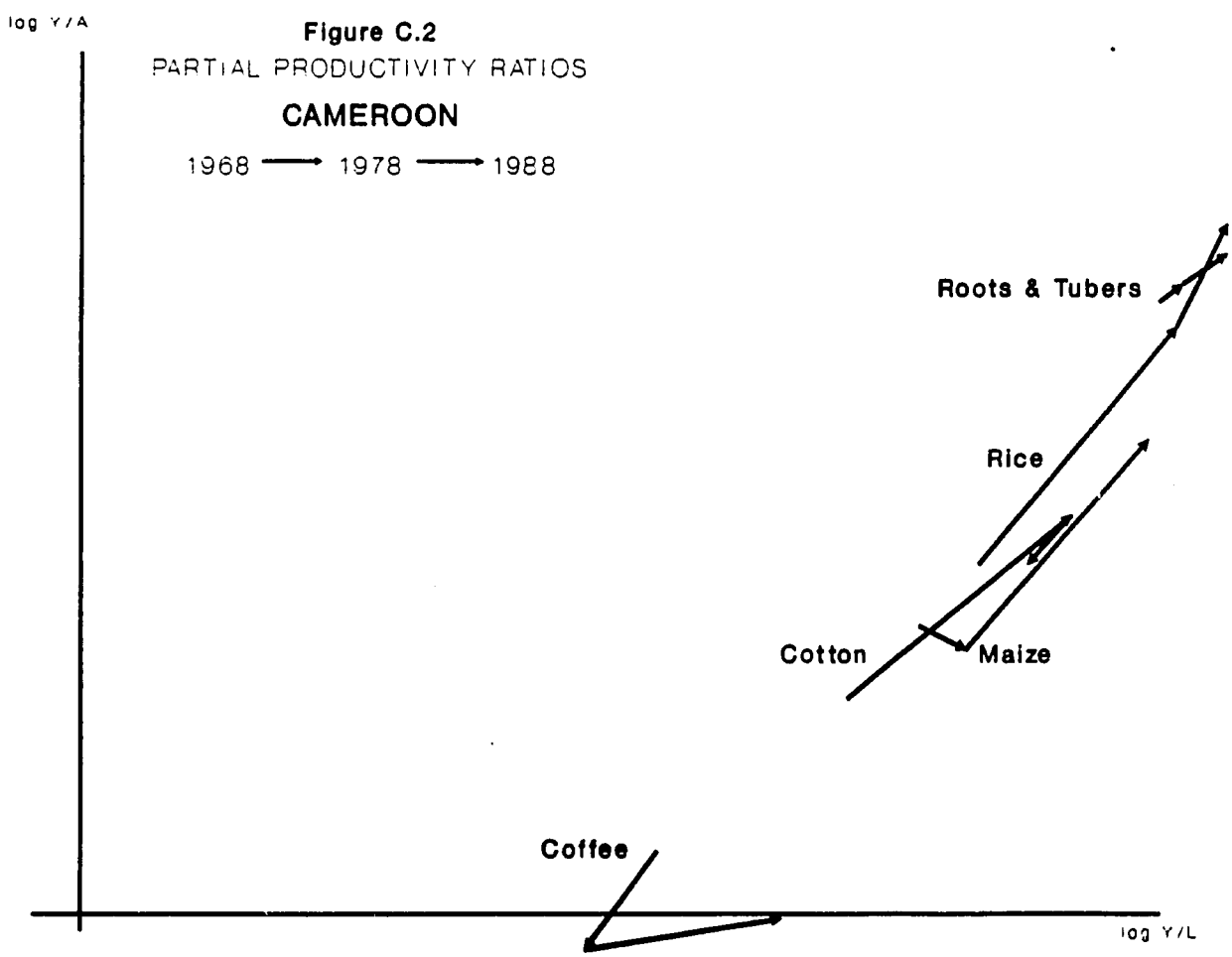

log Y/A
Figure C.1
PARTIAL PRODUCTIVITY RATIOS
KENYA
1968 → 1978 → 1988
Rice
R & T
Maize
Coffee
Cotton
log Y/L


log Y/A
Figure C.2
PARTIAL PRODUCTIVITY RATIOS
CAMEROON
1968 → 1978 → 1988
Roots & Tubers
Rice
Cotton
Maize
Coffee
log Y/L

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Only in cotton did Cameroon's yield levels exceed Kenya's. In 1968, Cameroon's cotton yield was approximately 75 greater than Kenya's. As cotton yields increased in Cameroon and fell in Kenya during the 1970s, this gap grew to nearly 340 percent by 1978. Kenya's relatively stronger yield performance during the 1980s narrowed the gap to roughly 160 percent by 1988.

On the other hand, Cameroon's labor productivity tended both to exceed Kenya's and to grow more rapidly. Cameroonian cotton labor productivity, for instance was approximately nine times that of Kenya in 1968. During the 1970s, this gap increased to nearly 30-fold by 1978, and was still roughly 18-fold in 1988. The only commodities for which the levels of labor productivity were comparable between the two countries were roots and tubers.

The different rates of population growth between Kenya and Cameroon play a role in explaining the difference in these trends. From 1965 to 1973, Kenya's population grew at the average annual rate of 3.4 percent; from 1973 to 1980, the rate accelerated to 3.8 percent per year, and from 1980 to 1987, Kenya's population grew by over 4 percent per year. In contrast, Cameroon's rate of population growth in these three periods was 2.4 percent, 3.1 percent, and 3.2 percent, respectively. These effects are seen most clearly in the context of equation (3), which related changes in labor productivity to changes in yield and changes in area per worker.

The results presented above show that yields in Cameroon tended to grow more rapidly than yields in Kenya. Assuming that area cultivated remained roughly constant, the difference in population growth rates implies that area per worker fell more rapidly in Kenya than it did in Cameroon. The logic of equation (3) suggests that these trends could only be consistent with faster increases in labor productivity in Cameroon than in Kenya.

While differential rates of population growth are not the sole explanation for these marked differences in partial productivity ratios between Kenya and Cameroon, the effects of population growth on productivity are substantial. Other potential explanations include specific aspects of each country's agricultural research activities, climactic factors, differential rates of urbanization, and policy influences.

APPENDIX D

DERIVATION OF TOTAL FACTOR PRODUCTIVITY FROM TIME-SHIFTING PRODUCTION FUNCTIONS

DERIVATION OF TOTAL FACTOR PRODUCTIVITY FROM TIME-SHIFTING PRODUCTION FUNCTIONS

This appendix develops in greater technical detail the notion of total factor productivity in the context of time-shifting production functions.

In general, a production function with disembodied technical change takes the form

$$y = f(L,K,t) \tag{D.1}$$

This says that total quantity produced, y, is some function of labor, L, capital, K, and time, t. Or, more specifically,

$$y(t) = f(L(t), K(t), t) \tag{D.2}$$

which indicates that these terms are themselves functions of time.

One can then distinguish between changes in factor intensity and changes in productivity over time by observing the time derivative of equation (D.2)

$$\frac{dy}{dt} = \frac{\partial f}{\partial L}\frac{dL}{dt} + \frac{\partial f}{\partial K}\frac{dK}{dt} + \frac{\partial f}{\partial t} \tag{D.3}$$

The first two terms on the right-hand side of equation (D.3) reflect movements *along* the production function (i.e., the changes in output explained by increases in the use of capital and labor); the final term measures the *shift* of the function itself.[1]

As Intrilligator demonstrates, dividing both sides of equation (D.3) by output transforms the production function into rates of change in terms of elasticities, that is

$$\frac{1}{y}\frac{dy}{dt} = \left(\frac{L}{y}\frac{\partial y}{\partial L}\right)\frac{1}{L}\frac{dL}{dt} + \left(\frac{K}{y}\frac{\partial y}{\partial K}\right)\frac{1}{K}\frac{dK}{dt} + \frac{1}{y}\frac{\partial y}{\partial t} \tag{D.4}$$

Note that the bracketed terms on the right-hand side of (D.4) are simply the production elasticities, which are estimated econometrically (these are the β's in the regression equation).

[1] See Intrilligator (1978), Chapter 8 for details.

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For the Cobb-Douglas case, where A is a scale parameter and λ is the rate of disembodied technical change, the production function is

$$y = (Ae^{\lambda t})L^{\beta_1}K^{\beta_2} \tag{D.5}$$

which one typically estimates in natural logs as

$$\ln y = \ln A + \beta_1 \ln L + \beta_2 \ln K + \lambda t \tag{D.6}$$

From equation (D.6), one estimates the rate of technical change, λ, as the residual growth in output *not* explained by the elasticity-weighted growth in inputs

$$\lambda = \frac{1}{y}\frac{dy}{dt} - \beta_1\left(\frac{1}{L}\frac{dL}{dt}\right) - \beta_2\left(\frac{1}{K}\frac{dK}{dK}\right) \tag{D.7}$$

Equation (D.7) is essentially the original framework adopted by Solow (1957). The rate of technical change, λ, thus defines the rate of growth in *total factor productivity* (TFP).

APPENDIX E

REGRESSION RESULTS AND STATISTICAL TESTS

REGRESSION RESULTS AND STATISTICAL TESTS

This appendix presents the full regression results underlying the analysis in Chapter 5. Table E.1 presents the results of random effects estimation of the commodity-specific production functions of the form

$$y_{jit} = \beta_0 + \beta_1 l_{jit} + \beta_2 a_{jit} + \beta_3 f_{it} + \beta_4 T78 + \beta_5 T88 + (\mu_{ji} + \varepsilon_{jit}) \qquad \textbf{(E.1)}$$

As described in Chapter 5, the lower case letters, l, a, and f, represent the logs of the quantities of labor, area, and fertilizer used as inputs in the production of commodity j in country i. T78 and T88 are dummy variables, allowing the production function to shift position over time. The magnitude of these shifts reflect TFP changes, which were reported in Table 3 in Chapter 5.

The individual time dummies at this level of aggregation suggest that productivity growth (relative to the starting point of 1968) was limited largely to the 1980s.

In each of the models presented in Table E.1, the Lagrange Multiplier test strongly indicate the significance of country-specific effects (e.g., $\mu_i \neq 0$). In addition, Hausman specification tests suggested that the random effects approach was more appropriate than fixed effects in each case except maize. Yet, implausible coefficients in the fixed effects specification for maize suggested that the random effects approach was preferable despite the Hausman test. In fact, fixed effects models yielded implausible results for each commodity.

Table E.1 also presents the results of various F-tests for statistical significance in the dummy variables. The joint F scores on the time dummies are such that we fail to reject the null hypothesis of no technical change for each commodity. Indeed, at the .05 level of certainty, we also fail to reject the null hypothesis of no shift from 1968 to 1978 and from 1978 to 1988. Yet, relaxing the required level of certainty to .10, we may reject the null hypothesis of no change in the intercept between 1978 and 1988 for cotton and rice.

Table E.2 presents the results of the production functions expanded to include time/region interaction terms for each of the five regions in each of the three time periods. The underlying production function in this case is specified (as ordinary least squares) as

$$\begin{aligned} y_{jit} = {} & \beta_0 + \beta_1 l_{jit} + \beta_2 a_{jit} + \beta_3 f_{it} + \sum_{r=1}^{m-1} \sum_{t=1}^{T} \beta_{rt} (region_r * time_t) \\ & + \sum_{t=2}^{T} \beta_t (region_M * time_t) + \varepsilon_{jit}; \qquad m = regions\ 1...5,\ t = 1...3 \end{aligned} \qquad \textbf{(E.2)}$$

This specification allows each region to have its own intercept in each period, thus yielding estimates of technical change at the regional level.

TABLE E.1 Random Effects Estimates of Commodity Production Functions

	COFFEE	COTTON	MAIZE	RICE	RTS/TBS
const	-.724 (.201)***	-.226 (.304)	-.157 (.165)	.388 (.147)***	1.76 (.150)***
LABOR	.181 (.156)	-.135 (.154)	.185 (.083)***	.142 (.106)*	.121 (.089)*
AREA	.775 (.159)***	.981 (.168)***	.811 (.091)***	.812 (.117)***	.853 (.096)***
FERT	.006 (.028)	.114 (.030)***	.042 (.017)***	.007 (.026)	-.019 (.010)**
TIM78	.064 (.113)	-.106 (.101)	.058 (.061)	.008 (.098)	.059 (.033)***
TIM88	-.006 (.117)	.187 (.107)**	.108 (.066)**	.193 (.102)**	.095 (.036)***
R^2	.916	.840	.957	.938	.958
# obs	72	57	111	93	117
H_0: $T68 = T78$ F_{calc} =	.17 < $F_{1,66} \approx 3.99$	.87 < $F_{1,51} \approx 4.03$	.68 < $F_{1,105} \approx 3.94$	.107 < $F_{1,87} \approx 3.95$	.21 < $F_{1,111} \approx 3.93$
H_0: $T78 = T88$ F_{calc} =	.14 < $F_{1,66} \approx 3.99$	3.32[b] < $F_{1,51} \approx 4.03$	.30 < $F_{1,105} \approx 3.94$	2.65[b] < $F_{1,87} \approx 3.95$	.05 < $F_{1,111} \approx 3.93$
H_0: $T68 = T78 = T88$ F_{calc} =	.108 < $F_{2,66} \approx 3.14$	1.66 < $F_{2,51} \approx 3.18$	1.72 < $F_{2,108} \approx 3.08$	2.06 < $F_{2,87} \approx 3.10$	.199 < $F_{2,111} \approx 3.08$
Hausman	5.22 P=.39	6.3 P=.28	15.83 P=.007	3.74 P=.59	8.22 P=.14
Lagrange Mult.	LM=13.64 P=.000	LM=14.3 P=.000	LM=25.45 P=.000	LM=12.8 P=.000	LM=91.77 P=.000

* ==> significant at .20
** ==> significant at .10
*** ==> significant at .05

b ==> borderline at .10

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TABLE E.2 Unrestricted OLS Production Functions with Time/Region Interactions

	COFFEE	COTTON	MAIZE	RICE	Rt/Tb
const	-.144 (.272)	.466 (.331)*	-.354 (.169)***	.184 (.192)	1.61 (.158)***
LABOR	.007 (.117)	.099 (.140)	.133 (.062)***	.015 (.086)	.147 (.066)***
AREA	.863 (.115)***	.678 (.153)***	.890 (.073)***	.967 (.099)***	.841 (.074)***
FERT	.017 (.028)	.176 (.039)***	.041 (.021)**	-.002 (.028)	.001 (.020)
SAHEL78	NA	-.087 (.294)	.067 (.185)	.083 (.231)	.057 (.203)
SAHEL88	NA	.207 (.298)	.149 (.187)	.530 (.236)***	.015 (.206)
EAST68	.041 (.358)	-.250 (.320)	.314 (.211)*	.593 (.260)***	.287 (.217)*
EAST78	.195 (.363)	-.377 (.319)	.399 (.213)**	.715 (.255)***	.298 (.219)*
EAST88	.301 (.358)	-.127 (.321)	.452 (.214)***	.703 (.260)***	.402 (.221)**
WEST68	-.540 (.320)**	.230 (.317)	.128 (.188)	.009 (.215)	.357 (.203)**
WEST78	-.547 (.313)**	-.448 (.329)*	.063 (.189)	-.004 (.223)	.357 (.205)**
WEST88	-.579 (.313)**	-.149 (.344)	.085 (.193)	.178 (.225)	.367 (.207)**
SOUTH68	(excluded)	-.474 (.379)	-.139 (.190)	.040 (.265)	-.056 (.211)
SOUTH78	-.104 (.360)	-.635 (.401)*	.119 (.194)	-.123 (.277)	-.010 (.215)
SOUTH88	-.423 (.361)	-.353 (.408)	-.006 (.194)	.138 (.277)	.003 (.215)
CENT68	-.534 (.338)*	-.248 (.403)	.112 (.213)	-.060 (.277)	-.142 (.227)
CENT78	-.337 (.345)	-.238 (.404)	-.044 (.214)	-.037 (.273)	-.051 (.229)
CENT88	-.344 (.340)	-.177 (.404)	.299 (.215)*	-.174 (.276)	.016 (.229)
R^2	.938	.874	.964	.956	.966
# obs	72	57	111	93	117

*=> significant at .20; **=> significant at .10; ***=> singificant at .05

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In these regressions, the excluded interaction term is Sahel/1968. Thus, the shifts in the other intercepts are measured relative to that baseline. This implies that the standard errors reported in the table indicate the certainty with which we can distinguish statistically between the given intercept and Sahel/1968. Yet, a more relevant question is whether or not the estimated intercepts are different over time *within* a given region. Testing such differences requires a fairly elaborate set of restricted regressions.

TFP Change in Maize

Table E.3 summarizes the intercept shifts for maize production. The numbers in the first three columns of Table E.3 are the percentage shift (e.g., rate of total factor productivity change) over the entire period indicated. Thus, for maize in the Sahel, productivity increased by 14.9 percent between 1968 and 1988, which is the sum of a 6.7 percent increase from 1968-78 and an 8.2 percent change from 1978-88. Given the assumption in equation (5) of a constant rate of technical change, this implies an annual average increase of 0.75 percent during the two decades from 1968-88.

TABLE E.3 Regional Productivity Change for Maize, 1968-1988

Region	Total % Δ 1968-78	Total % Δ 1978-88	Total % Δ 1968-88	Avg. Annual % 1968-88
Sahel	6.7	8.2	14.9	.746
East	8.5	5.3	13.9	.69
West	-6.5	2.1	-4.3	-.22
South	25.8	-12.5	13.3	.66
Central	-15.7	34.3	18.6	.93

Table E.3 confirms the existence of significant heterogeneity across regions (for a given crop). During the 1970s maize productivity in Southern Africa increased by over 25 percent while productivity in Central Africa fell by nearly 16 percent during the same period. On average over both decades, however, the diverse patterns over time tend to balance out. The total percent change in TFP from 1968 to 1988 was similar for all regions except West Africa. In terms of yearly average rates of change, Southern and East Africa are virtually identical, and Sahel and Central grew only slightly faster. In contrast, factor productivity in West Africa declined by an average of 0.22 percent per year from 1968 to 1988.

It is also interesting to consider the stability of these productivity changes. For instance, the rates of productivity change in the Sahel and East Africa were relatively consistent over time. In contrast, West, Central, and Southern Africa each switched between positive and

negative productivity change across decades, the rates increasing in West and Central Africa, but falling drastically over time in Southern Africa.

The large productivity gains for maize in Southern Africa during the 1970s (and to some extent in East Africa, as well) reflect the development, release, and widespread adoption of several highly successful maize varieties in Zimbabwe (and Kenya). In some measure, the productivity gains in Central Africa during the subsequent decade reflect the adaption of those varieties for release there. This was true of Cameroon, at least.

Tests of the statistical significance of these results are presented at the end of this appendix (Table E.10). In general, the tests indicate that the TFP changes for maize described in this section are not statistically significant. This finding does not mean that no other technical change occurred, but rather that there was substantial heterogeneity within regions (and a limited number of observations).

TFP Change in Coffee

TFP trends in coffee production have been more disappointing. As Table E.4 shows, coffee productivity grew at a slower pace in the 1980s than in the 1970s in each of the four relevant regions. Indeed, coffee productivity in West, Southern, and Central Africa *declined* during the 1980s.

TABLE E.4 Regional Productivity Change for Coffee, 1968-1988

Region	Total % Δ 1968-78	Total % Δ 1978-88	Total % Δ 1968-88	Avg. Annual % 1968-88
East	15.4	10.6	26.0	1.30
West	0.71	-3.2	-3.9	-.195
South	-10.5	-31.8	-42.3	-2.11
Central	19.7	-0.70	.19	0.95

On average from 1968 to 1988, annual TFP change in coffee was positive in two regions (East and Central) and negative in two (West and Southern). Performance in Southern Africa was particularly negative, going from bad to worse over time. TFP for coffee in Southern Africa declined by over 2 percent per year during the two decades.

Only in East Africa did coffee productivity continue to grow during the 1980s. TFP growth in that region was 15.4 percent during the 1970s and 10.6 percent during the 1980s, averaging out to 1.3 percent per year for the two decades. Kenya, again, is the most likely source of these gains. Kenya stands out for the sophistication of its coffee research system and

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for its relatively highly developed coffee export marketing system. The fact that coffee productivity grew more slowly in each region during the 1980s could, in part, reflect the collapse of international coffee markets towards the end of that decade.

TFP Change in Cotton

In contrast to the poor productivity trends in coffee, cotton productivity performed quite well. As Table E.5 demonstrates, the rate of growth in cotton TFP increased in every region from the 1970s to the 1980s. Indeed, in three of the five regions, positive growth in the 1980s more than compensated on average for productivity losses suffered by cotton in the previous decade. Over the two decades combined, the highest average annual rate of TFP growth in cotton came in the Sahel, which increased at the rate of just over 1 percent per year. West Africa was the only region that suffered productivity losses on average. In that case, despite having the fastest rate of productivity growth during the 1980s, those gains were insufficient to compensate fully for the greater losses of the 1970s.

TABLE E.5 Regional Productivity Change for Cotton

Region	Total % Δ 1968-78	Total % Δ 1978-88	Total % Δ 1968-88	Avg. Annual % 1968-88
Sahel	-8.7	29.4	20.7	1.03
East	-12.7	24.9	11.5	0.6
West	-45.0	29.9	-15.1	-0.8
South	-16.0	28.2	12.2	.61
Central	0.96	6.12	7.1	.35

It is also interesting to note the similarity in the rates of productivity increase in the 1980s for all of the regions except Central Africa. This may suggest that cotton technology is more transferable across regions than technologies developed for other commodities for which cross-regional progress was less uniform.

TFP Change in Rice

The productivity results are more mixed for rice (as seen in Table E.6). Three of the five regions (Sahel, West, and Southern) registered positive productivity growth during the 1980s, though in each of those cases progress had been negative during the 1970s. In contrast, the two regions in which rice resources had become less productive during the 1970s rebounded during the 1980s, with the greatest reversal coming in Southern Africa. On balance, however, this reversal just barely compensated for earlier losses.

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TABLE E.6 Regional Productivity Change for Rice, 1968-1988

Region	Total % Δ 1968-78	Total % Δ 1978-88	Total % Δ 1968-88	Avg. Annual % 1968-88
Sahel	-4.5	45.3	40.7	2.04
East	12.0	-8.5	3.6	0.18
West	-9.3	15.2	6.9	0.34
South	-24.6	26.0	1.4	0.07
Central	2.19	-14.1	-11.9	-0.60

The fastest average annual rate of TFP increase in rice came in the Sahel. This, most likely, was the result of expansion in irrigated perimeters during the 1980s. Central Africa was the only region in which rice TFP declined on average from 1968 to 1988. In Cameroon, for example, large rice production projects collapsed under the weight of unsustainably high subsidy costs and low world market rice prices during those years.

As described in the last part of this appendix, among these movements in rice TFP, only the measurements for Sahel/1978-88 and Sahel/1968-88 are statistically significant.

TFP Change in Roots and Tubers

Roots and tubers remain important subsistence crops for many across Sub-Saharan Africa. Yet, these less preferred and largely non-tradable commodities have received relatively little attention from agricultural researchers. The resulting lack of technical change for roots and tubers is clearly seen in the TFP measurement for these crops reported in Table E.7.

TABLE E.7 Regional Productivity Change for Roots and Tubers

Region	Total % Δ 1968-78	Total % Δ 1978-88	Total % Δ 1968-88	Avg. Annual % 1968-88
Sahel	5.7	-4.23	1.5	0.075
East	1.1	10.4	11.5	0.58
West	0.02	1.0	1.02	0.05
South	4.6	1.3	5.9	0.30
Central	9.1	6.8	15.9	0.8

The range of productivity changes in roots and tubers is much narrower than those for any of the other commodities. The greatest one decade rate of change was in East Africa during

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the 1980s, where TFP increased by just over 10 percent. In general, however, the rates of change as well as the changes in those rates across decades were quite small. In most cases (Sahel during the 1980s being the sole exception), productivity change was positive, though slow. One also sees little variation across regions in TFP growth rates for roots and tubers, and none of these changes are statistically significant.

Cross-Region Comparisons of TFP

These results for TFP change can be rearranged to facilitate cross-commodity comparisons within regions. Figures E.1 through E.5 juxtapose the productivity changes for various commodities within each of the five regions. Within each region, the darker bars on the left (for each commodity) indicate the total change in TFP from 1968-78 (e.g., the rate per decade); the lighter bars indicate the rate from 1978-88. The numbers across the bottom of the charts are the twenty-year *annual* average (1968-88) rate of TFP change for the given commodity.

In this light, East Africa stands out for the most consistently positive TFP gains across commodities (see Figure E.1). With the exception of negative productivity change for rice in the 1980s and cotton in the 1970s, TFP growth was positive for East Africa for all commodities in both decades. In this sense, productivity growth in East Africa was clearly the most consistent over time and across commodities of any region. Yet, with the exception of roots and tubers, the rate of TFP growth over time declined across the board in East Africa. Compared with East Africa, productivity growth was significantly more volatile in each of the other regions.

Figure E.1
TFP Growth in East Africa

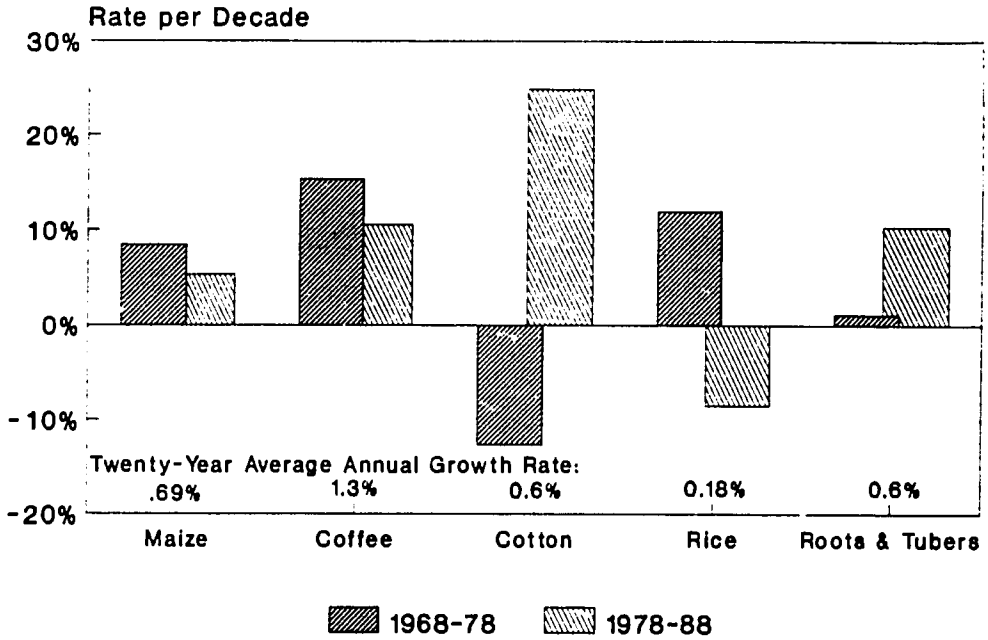

Figure E.2
TFP Growth in West Africa

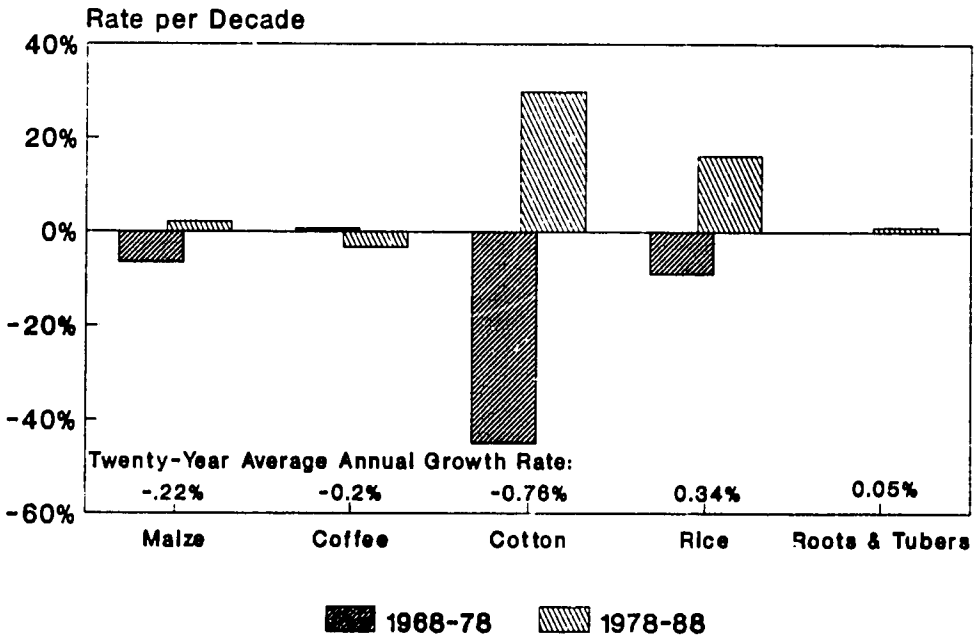

Figure E.3
TFP Growth in Southern Africa

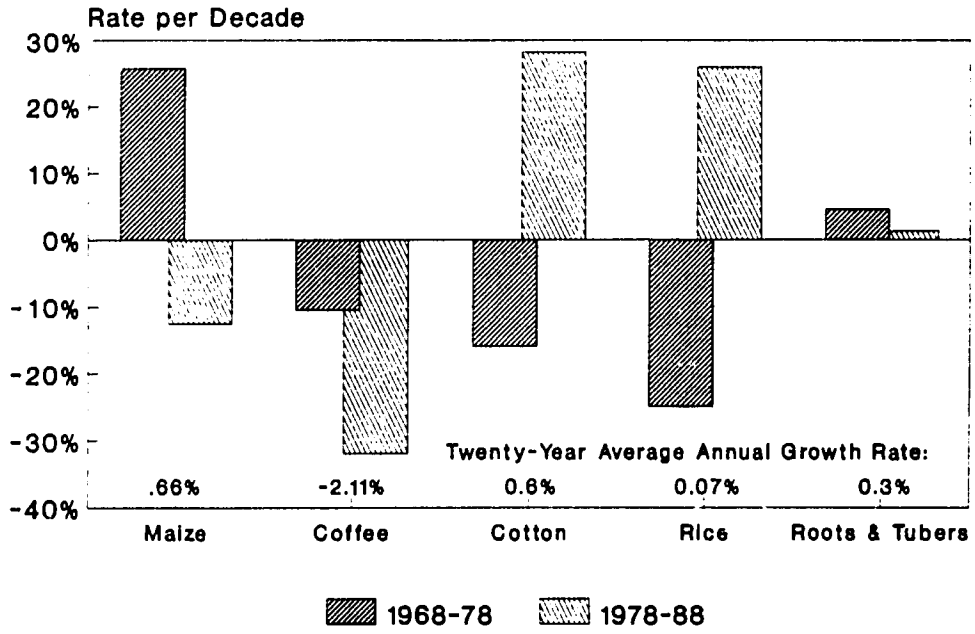

Figure E.4
TFP Growth in Central Africa

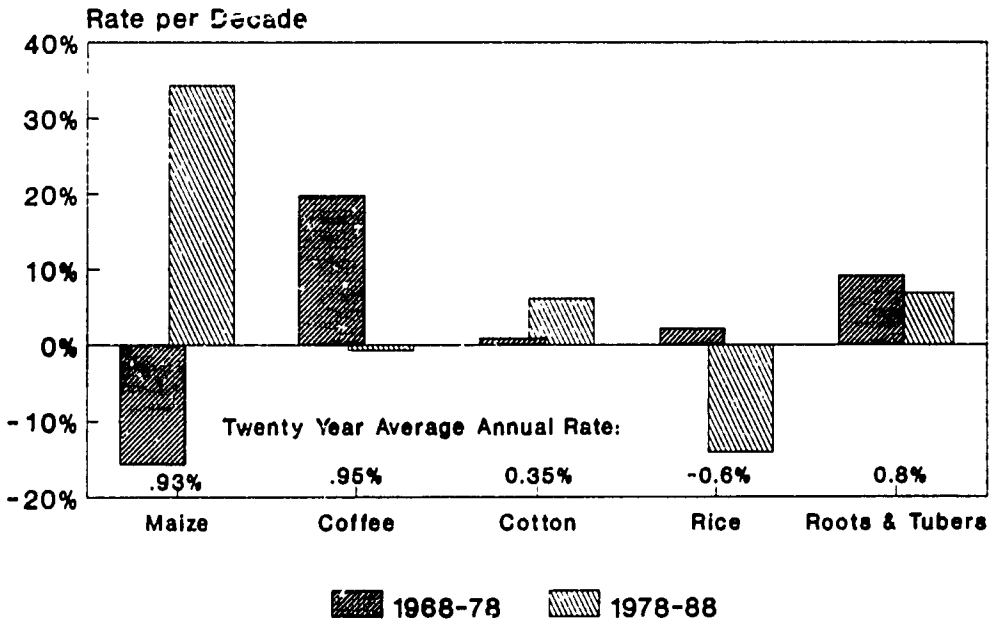

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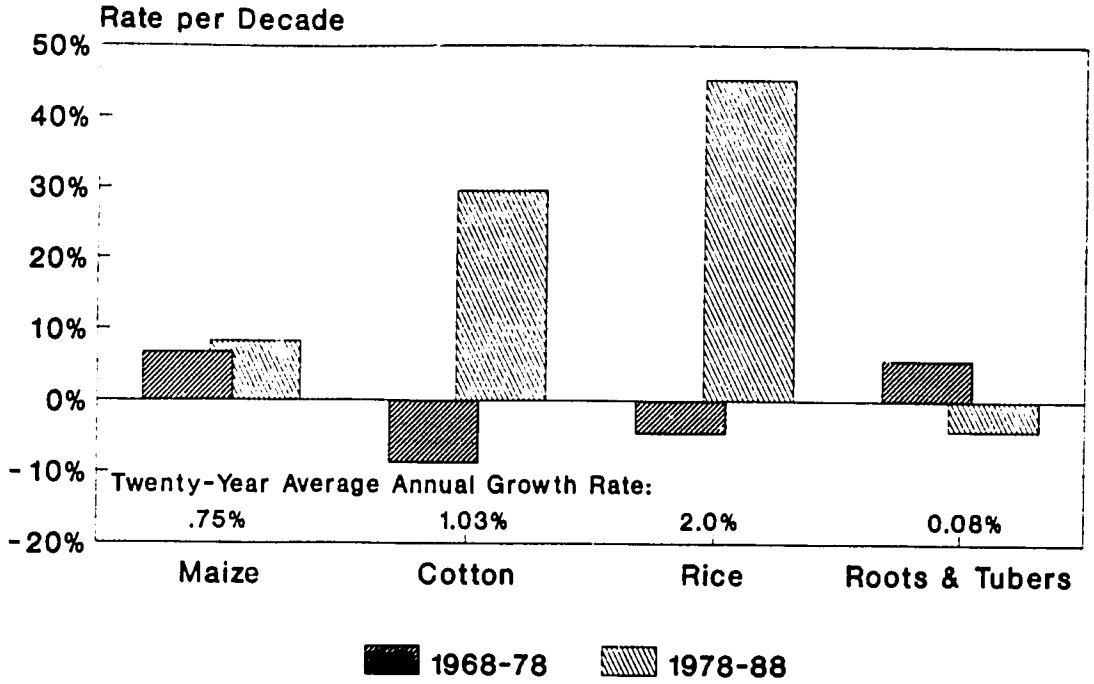
Figure E.5
TFP Growth in Sahel



At the other extreme, West (Figure E.2) and Southern Africa (Figure E.3) tended to have the weakest performance in TFP growth. Across commodities, West Africa's twenty-year annual average TFP growth was the lowest of any region for three of the five commodities. Southern Africa's twenty-year averages were the second lowest in three of five commodities, and lowest in one.

In terms of general improvement moving from the 1970s to the 1980s, however, West Africa was the best performer. TFP growth rates in West Africa accelerated over time for every commodity except coffee. In contrast, East Africa, where on average TFP grew much more rapidly than in West Africa for every commodity except rice, suffered a deceleration in TFP growth in four of five commodities.

The results for Central Africa (Figure E.4) are mixed, both in terms of the situation in the 1980s and the trend from the 1970s to the 1980s. In the Sahel (Figure E.5), TFP growth was clearly more positive in the 1980s than in the 1970s. Severe drought during the earlier decade certainly contributed to this result.

Significance Tests

Tables E.8 through E.12 report the results of F-tests of three alternative hypotheses. The first column of each table tests whether there was statistically significant technical change from

1968 to 1978 (i.e., are the intercepts for those two periods different from one another). This test is applied to each region separately and to all five regions jointly.

The second column in Tables E.8 through E.12 test whether the 1988 production functions were significantly different from the 1978 functions; and the third column of those tables tests whether there was any change over the course of both decades together (i.e., the null hypothesis is that the intercept for each of the three periods was the same). In these cases, too, the tests are applied first to each region separately, and then to all regions jointly. In each case, rejecting the null hypothesis with 95 percent certainty requires that the calculated F-scores reported in the tables exceed the critical value of F reported for each column. It is clear from even a cursory glance at these results that none of the estimated shifts are statistically significant at the .05 confidence level, with the exception of Sahelian rice in the 1980s and jointly from 1968 to 1988.

Yet, it is too simplistic to reject all of the results. Clearly, in some cases the shifts are not large enough to matter. Nonetheless, these statistical tests can also be taken to reflect the heterogeneity within regions which could result in small aggregate changes in the regional aggregate. In addition, the limited sample size suggests that there are relatively few observations underlying each regional aggregate. These factors contribute to the results of these F-tests.

TABLE E.8 F-tests for Productivity Changes—COFFEE

Region	$H_0^1: \beta_{r68} = \beta_{r78}$ N=72, q=1, k=15 $F_{1,57}^{crit} \approx 4.02$	$H_0^2: \beta_{r78} = \beta_{r88}$ N=72, q=1, k=15 $F_{1,57}^{crit} \approx 4.02$	$H_0^3: \beta_{r68} = \beta_{r78} = \beta_{r88}$ N=72, q=2, k=15 $F_{2,57}^{crit} \approx 3.17$
East	0.27	0.13	0.39
West	0.00	0.02	0.01
South	0.08	0.78	0.75
Central	0.45	0.00	0.29
All Regions Jointly	$.20 < F_{5,57}^{crit} \approx 2.38$	$.23 < F_{5,57}^{crit} \approx 2.38$	$.36 < F_{8,57}^{crit} \approx 2.11$

TABLE E.9 F-tests for Productivity Changes—COTTON

Region	$H_0^1: \beta_{r68} = \beta_{r78}$ N=57, q=1, k=18 $F_{1,39}^{crit} \approx 4.08$	$H_0^2: \beta_{r78} = \beta_{r88}$ N=57, q=1, k=18 $F_{1,39}^{crit} \approx 4.08$	$H_0^3: \beta_{r68} = \beta_{r78} = \beta_{r88}$ N=117, q=2, k=18 $F_{2,39}^{crit} \approx 3.23$
Sahel	.09	1.07	.5o
East	.132	.508	.25
West	1.59	.726	.85
South	.157	.496	.25
Central	0.00	.014	.01
All Regions Jointly	$.39 < F_{5,39}^{crit} \approx 2.45$	$.56 < F_{5,39}^{crit} \approx 2.45$	$.39 < F_{10,39}^{crit} \approx 2.07$

TABLE E.10 F-tests for Productivity Changes—MAIZE

Region	$H_0^1: \beta_{r68} = \beta_{r78}$ N=111, q=1, k=18 $F_{1,93}^{crit} \approx 3.95$	$H_0^2: \beta_{r78} = \beta_{r88}$ N=111, q=1,k=18 $F_{1,93}^{crit} \approx 3.95$	$H_0^3: \beta_{r68} = \beta_{r78} = \beta_{r88}$ N=111, q=2,k=18 $F_{2,93}^{crit} \approx 3.10$
Sahel	.805		.33
East	.153	.055	.204
West	.115	.013	.06
South	2.04	.487	1.05
Central	.427	2.04	1.02
All Regions Jointly	$.57 < F_{5,93}^{crit} \approx 2.31$	$.55 < F_{5,93}^{crit} \approx 2.31$	$.51 < F_{10,93}^{crit} \approx 1.93$

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TABLE E.11 F-tests for Productivity Changes—RICE

Region	$H_0^1: \beta_{r68} = \beta_{r78}$ N=93, q=1, k=18 $F_{1,75}^{crit} \approx 3.97$	$H_0^2: \beta_{r78} = \beta_{r88}$ N=93, q=1, k=18 $F_{1,75}^{crit} \approx 3.97$	$H_0^3: \beta_{r68} = \beta_{r78} = \beta_{r88}$ N=93, q=2, k=18 $F_{2,75}^{crit} \approx 3.12$
Sahel	0.13	4.21	3.14
East	0.19	0.002	0.12
West	0.004	0.80	0.49
South	0.35	0.91	0.46
Central	0.005	0.20	0.11
All Regions Jointly	$.18 < F_{5,93}^{crit} \approx 2.34$	$1.56 F_{5,75}^{crit} \approx 2.34$	$1.10 < F_{10,75}^{crit} \approx 1.96$

TABLE E.12 F-tests for Productivity Changes—ROOTS and TUBERS

Region	$H_0^1: \beta_{r68} = \beta_{r78}$ N=117, q=1, k=18 $F_{1,99}^{crit} \approx 3.94$	$H_0^2: \beta_{r78} = \beta_{r88}$ N=117, q=1, k=18 $F_{1,99}^{crit} \approx 3.94$	$H_0^3: \beta_{r68} = \beta_{r78} = \beta_{r88}$ N=117, q=2, k=18 $F_{2,99}^{crit} \approx 3.09$
Sahel	0.08	0.05	0.05
East	0.00	0.215	0.16
West	0.00	0.00	0.00
South	0.05	0.00	0.04
Central	0.14	0.08	0.22
All Regions Jointly	$.05 < F_{5,99}^{crit} \approx 2.30$	$.07 < F_{5,99}^{crit} \approx 2.30$	$.09 < F_{10,99}^{crit} \approx 1.92$

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APPENDIX F

COUNTRY-SPECIFIC FINDINGS ON GROWTH IN AGRICULTURAL VERSUS TOTAL LABOR PRODUCTIVITY

COUNTRY-SPECIFIC FINDINGS ON GROWTH IN AGRICULTURAL VERSUS TOTAL LABOR PRODUCTIVITY

This appendix presents the country-specific results underlying the regional aggregates discussed in Chapter 3. Recall that the analysis examined the relationship between average annual growth rates in labor productivity, both in agriculture and in the general economy. Figure 2 (Chapter 3) illustrated these results for a sample of Asian and Near East countries. In that analysis, Timmer discovered coherent relationships which for some countries reflected a growth-oriented integration of agriculture into the macro economies.

Figures F.1 through F.5 illustrate these relationships, comparing average labor productivity growth rate trends between three periods: 1965-73, 1973-80, and 1980-87. The top panel of each figure illustrates movements from the first to the second period; the bottom panels continue the story from the second to the third period.

The experience of certain individual countries is clear. Cameroon, for example (see Figure F.2), experienced rapid growth in aggregate labor productivity during the years of its oil boom, with virtually none of that increase deriving from agriculture. The lower panel, however, shows Cameroon's subsequent fate. Dutch disease followed the oil boom, reducing agricultural labor productivity, while declining oil prices in the later period contributed to a reversal of Cameroon's aggregate labor productivity growth during the 1970s.

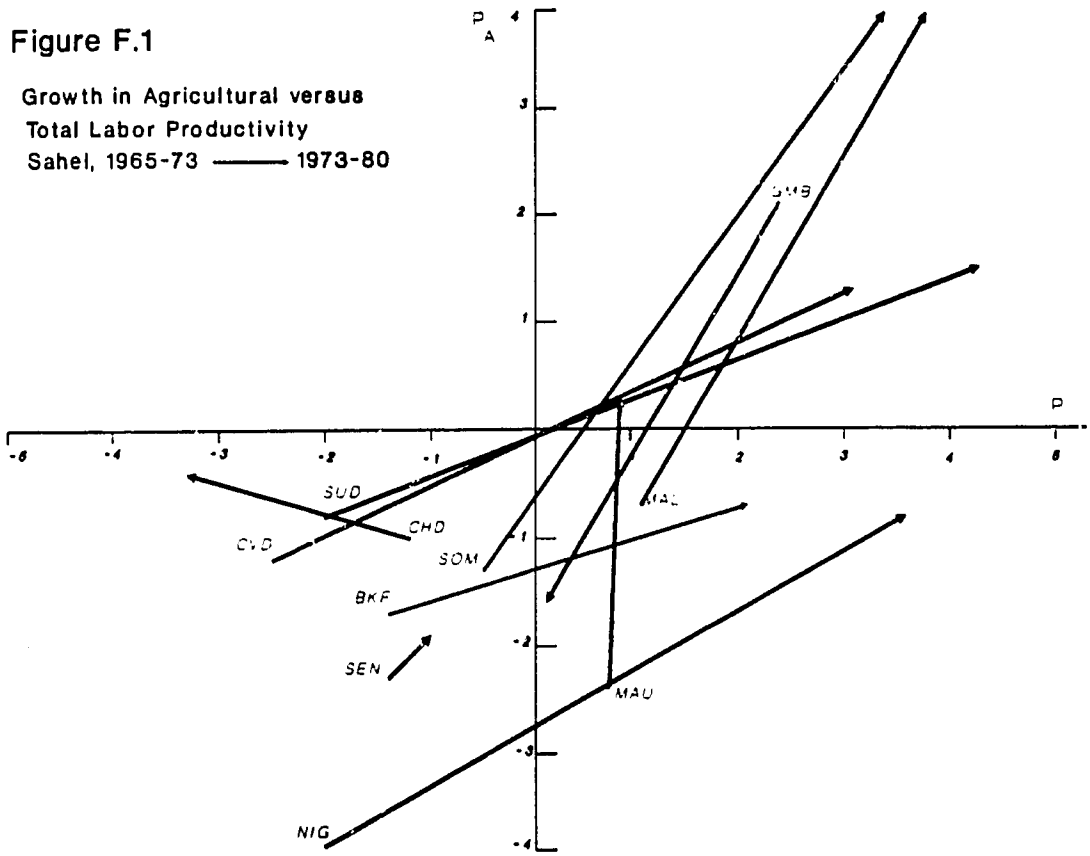
In general, however, Figures F.1 through F.5 reveal no systematic relationship whatsoever between agricultural and aggregate labor productivity growth in Sub-Saharan Africa. The fact that many of the countries demonstrate negative growth in one or both dimensions underlines the contrast with Asia. In the worst cases, such as Mozambique (Figure F.3), both measures were negative in all three periods and the trend was strongly negative. There are only eleven countries that remained in the positive quadrant through two consecutive periods, and only four of those countries remained so during all three periods (Cameroon, Kenya, Swaziland, and the Central African Republic).

The primary message to emerge from these figures lie, not in their details, but in the broad observation that the growth-oriented linkages between agricultural and aggregate labor productivity that are evident in the Asian context are almost completely absent in Sub-Saharan Africa.

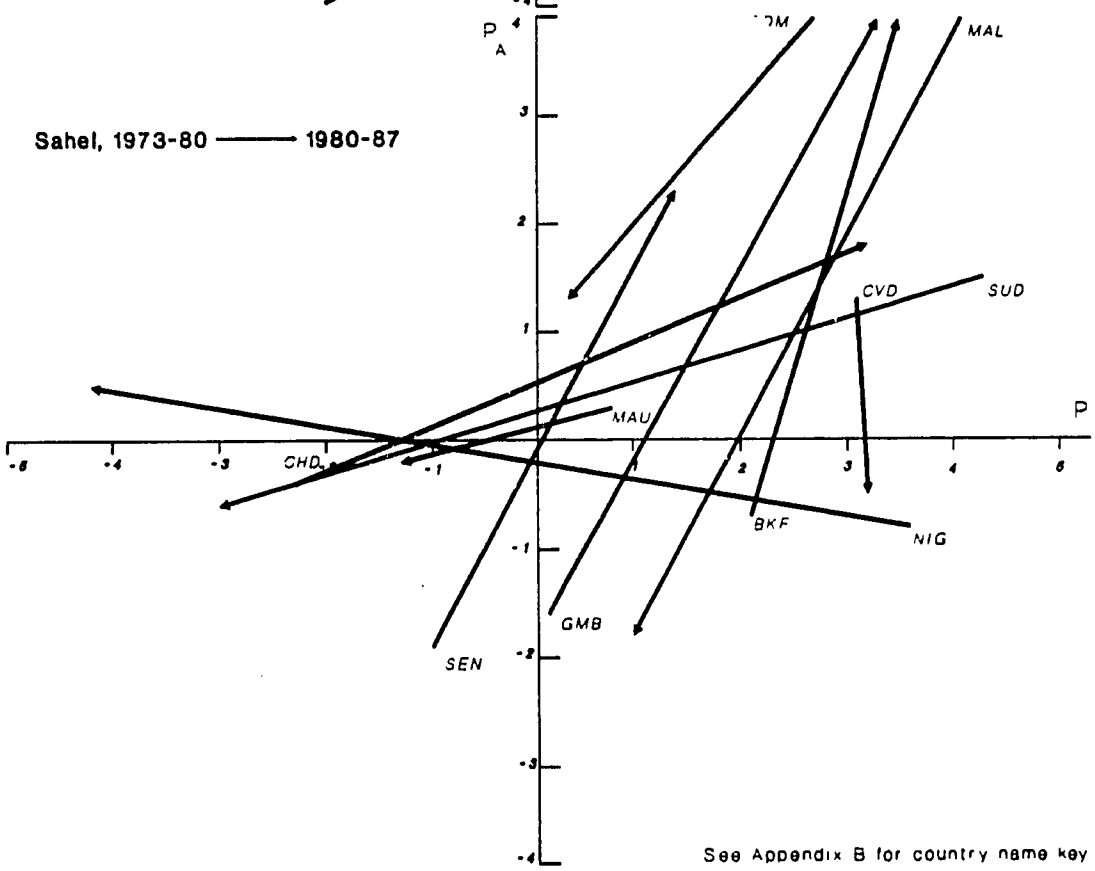
Figure F.1

Growth in Agricultural versus Total Labor Productivity

Sahel, 1965-73 ——→ 1973-80



Sahel, 1973-80 ——→ 1980-87



See Appendix B for country name key

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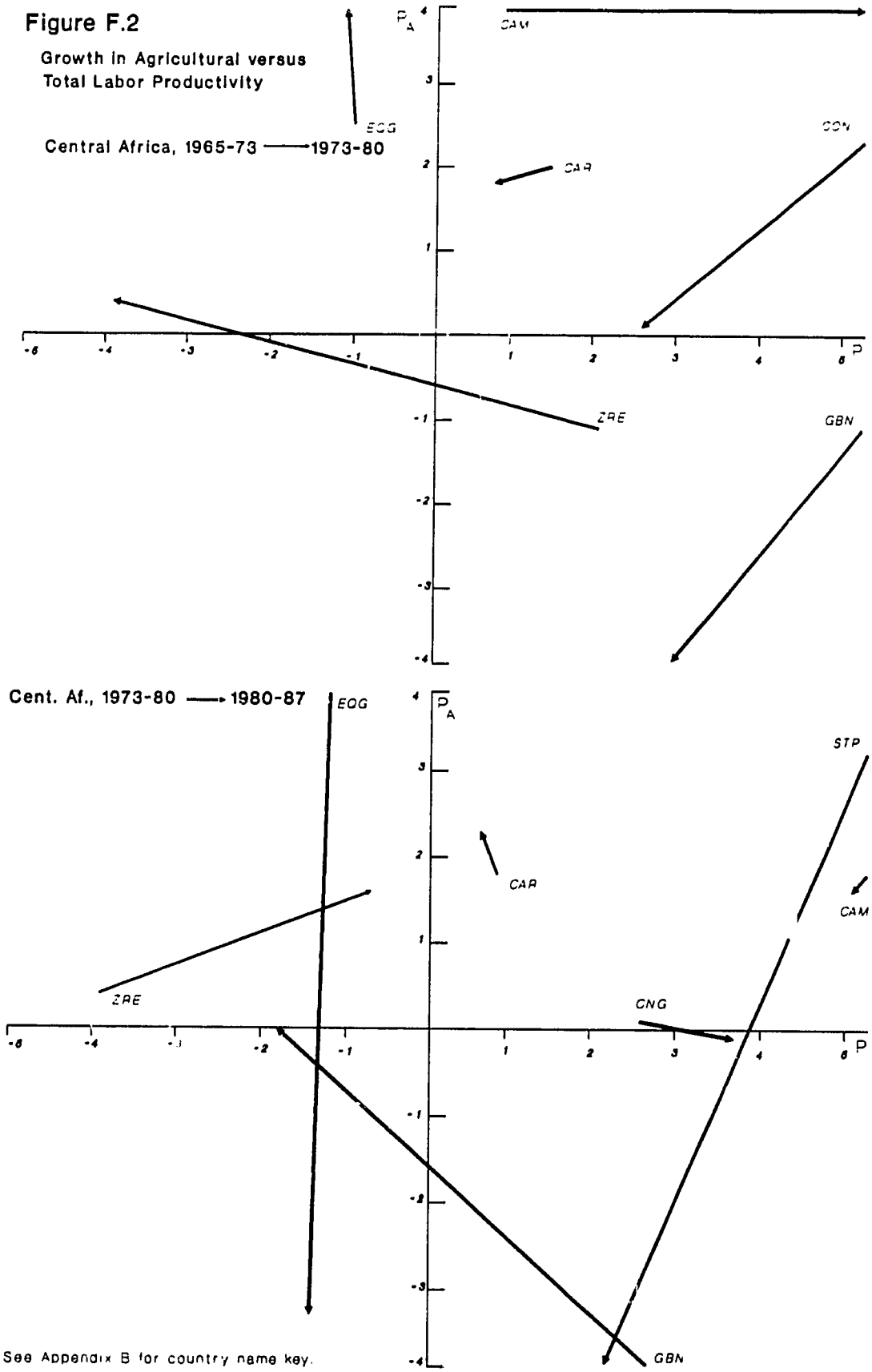
Figure F.2

Growth in Agricultural versus Total Labor Productivity

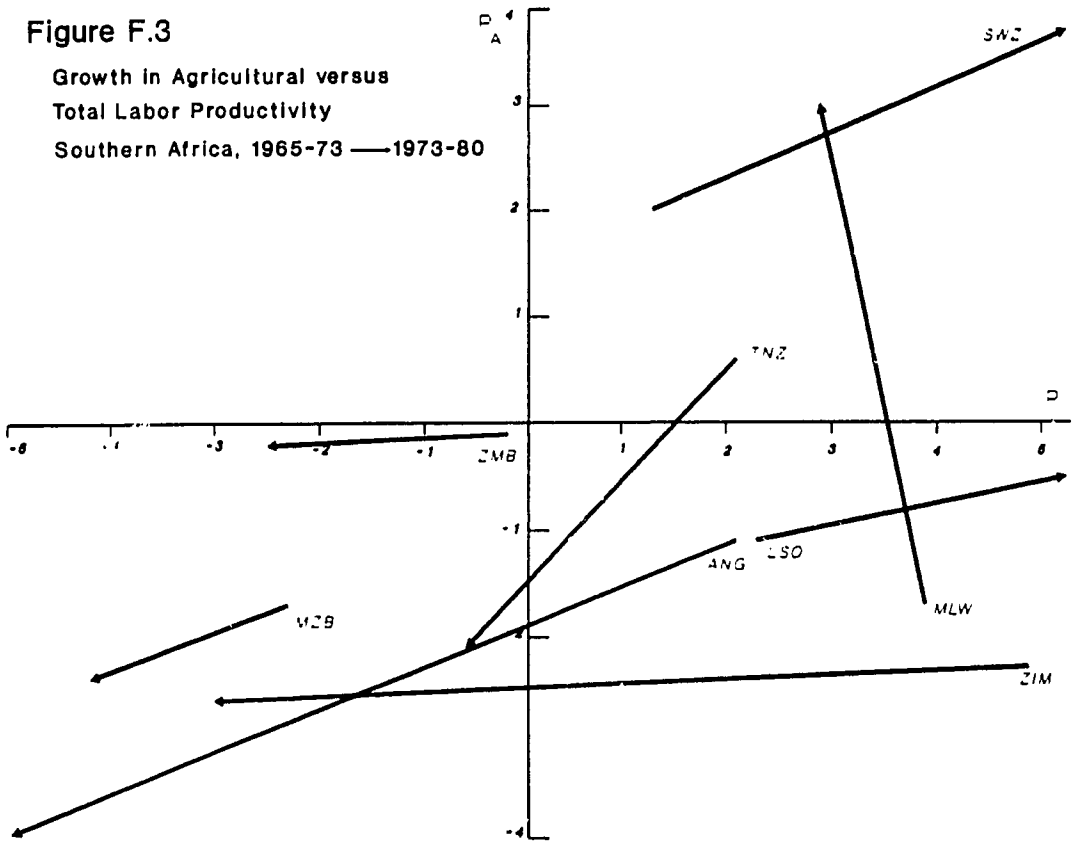


See Appendix B for country name key.

Figure F.3

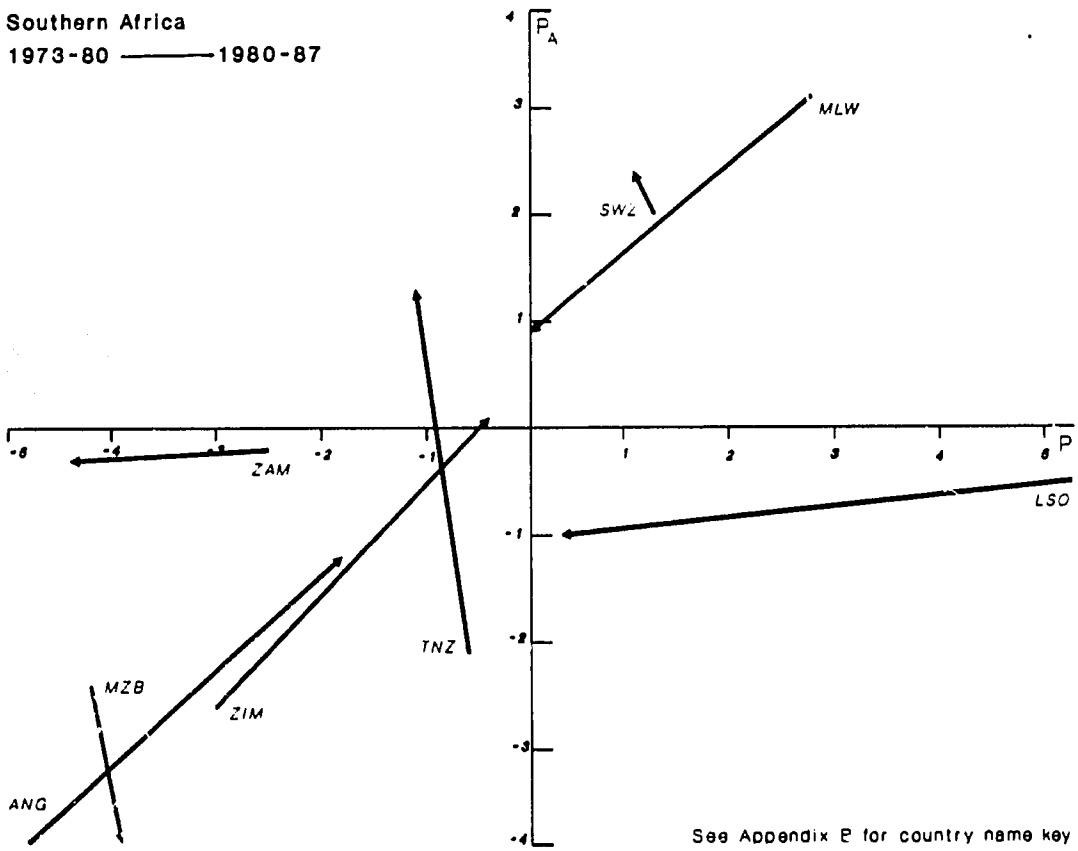
Growth in Agricultural versus Total Labor Productivity

Southern Africa, 1965-73 ⟶ 1973-80



Southern Africa

1973-80 ⟶ 1980-87



See Appendix E for country name key

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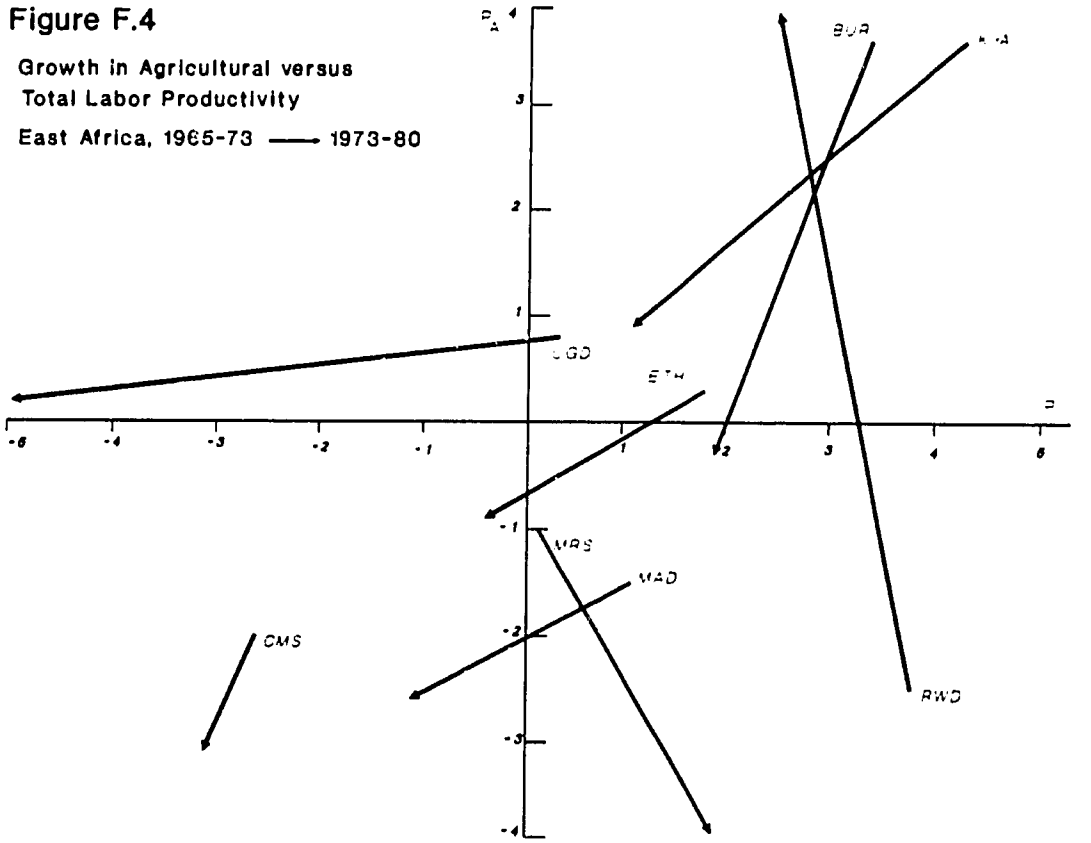
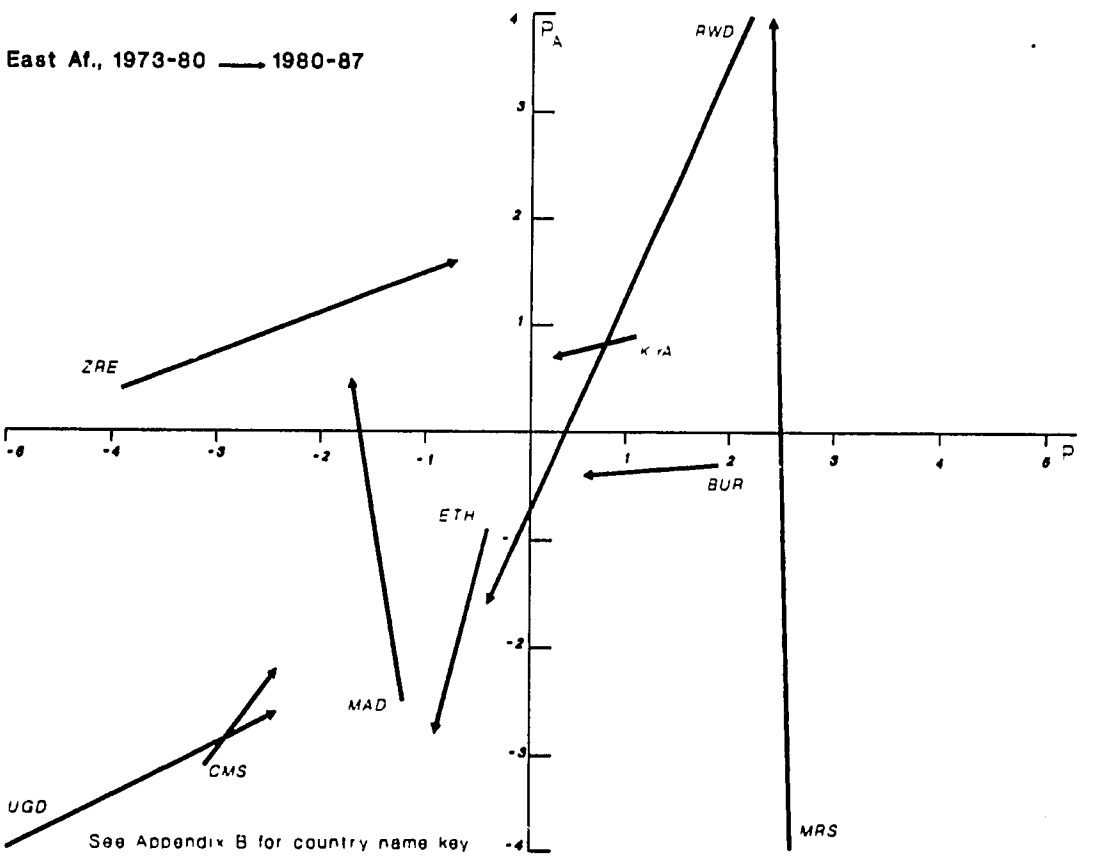
Figure F.4

Growth in Agricultural versus Total Labor Productivity

East Africa, 1965-73 ⟶ 1973-80



East Af., 1973-80 ⟶ 1980-87

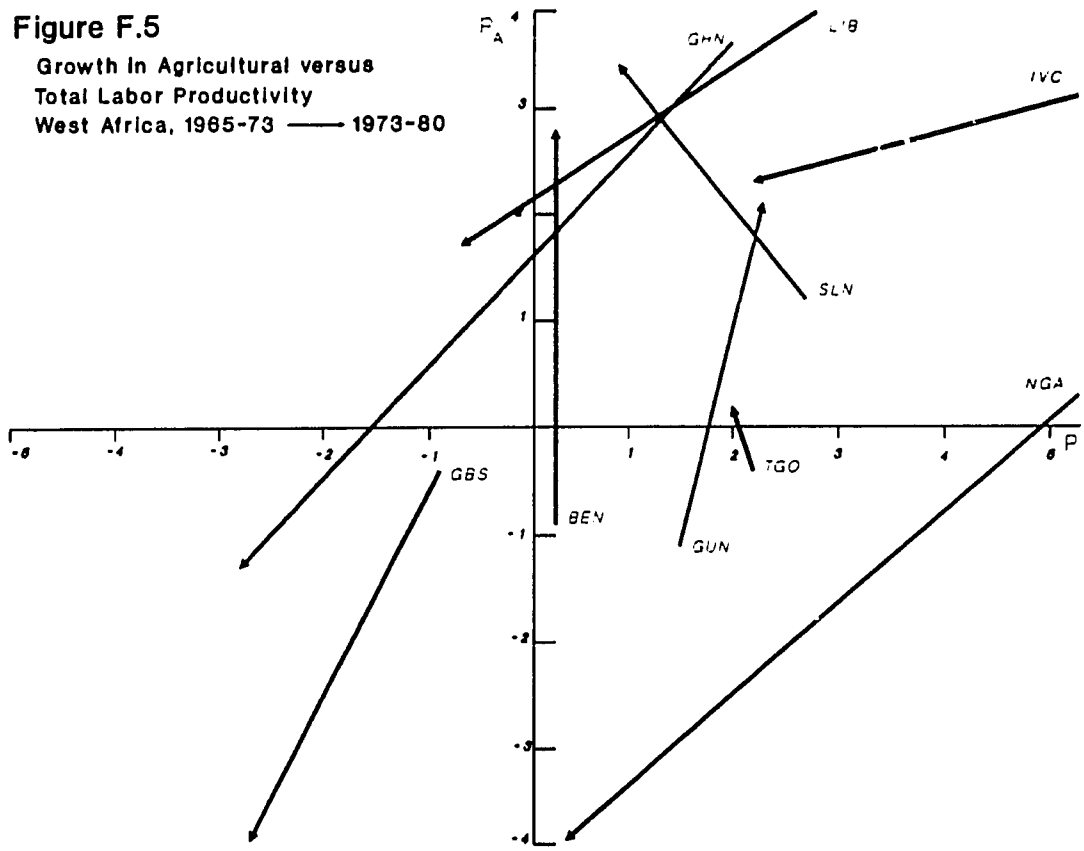


See Appendix B for country name key

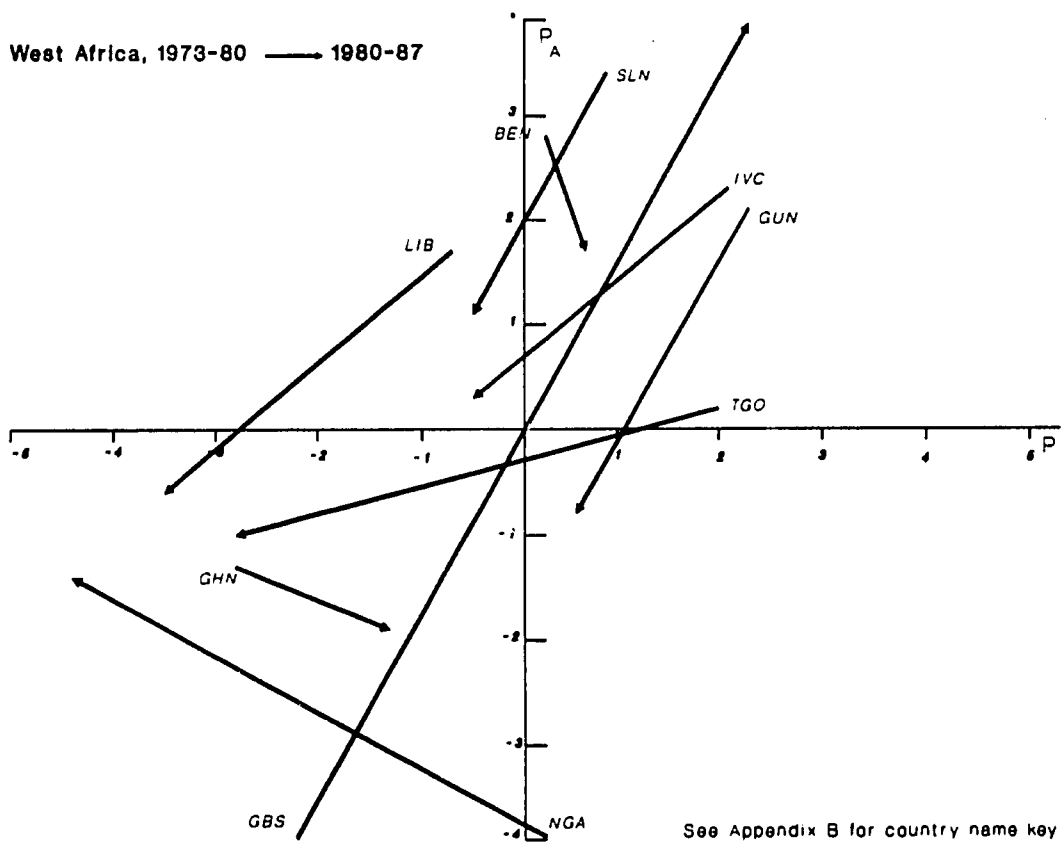
Figure F.5

Growth in Agricultural versus Total Labor Productivity

West Africa, 1965-73 ⟶ 1973-80



West Africa, 1973-80 ⟶ 1980-87



See Appendix B for country name key

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