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Agriculture and Economic Growth: Conceptual Issues and the Kenyan Experience

Steven Block
C. Peter Timmer

HIID

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Agriculture and Economic Growth: Conceptual Issues and the Kenyan Experience

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Executive Summary*

This report examines the role of agriculture in economic growth. The particular focus of our empirical analysis is on Kenya, though the report also adds to the existing literature by providing a new conceptual model of agriculture's role in the economic growth of poor countries. The literature on this subject is centuries old; yet, the realization that agriculture is central to the growth process of poor countries is relatively recent. This study builds upon the recent literature, most of which has focused on defining and measuring a set of market-based inter-sectoral growth linkages. The classic statement of these linkages is by Johnston and Mellor, who identified a set of five forward and backward linkages through which agriculture contributes to the growth process. The conceptual model presented in this study extends that framework to include a set of non-market linkages through which agricultural productivity in particular contributes to *non*-agricultural growth, and thus indirectly to economic growth in general.

The empirical chapters of this study present new evidence regarding agriculture's role in supporting Kenya's economic growth. One way of describing the relative contributions to growth of agriculture and non-agriculture is through growth multipliers. A growth multiplier summarizes the net effects of an exogenous increase in the income

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of a particular sector on the economy as a whole. In the absence of positive growth linkages, the multiplier effect would be zero. The results for Kenya indicate that the growth multiplier from agriculture is substantial, and on the order of two to three times the size of the growth multiplier from non-agriculture. Based on the econometric simulation model developed in this report, an additional dollar of income in Kenya's agricultural sector generates an additional 64 cents of income (most of it in non-agriculture), resulting in an agricultural growth multiplier of 1.64. In contrast, the growth multiplier from non-agriculture is 1.23. This result suggests that strategies to promote agricultural growth in Kenya can have large payoffs in terms of economic growth.

Several other simulations are possible with the model developed in this study. One experiment compares the growth multipliers associated with public investment in agriculture and non-agriculture. The simulation suggests that the growth effects of public investment in agriculture are substantially larger than those from investments in non-agriculture.

In addition to simulating "shocks" to sectoral income, the model can also be used to illustrate the effects of sustained increases in sectoral growth rates. For example, a sustained 1% increase in the growth rate of agricultural value added increases total GDP growth by 0.43 percentage points. A 1% increase in the growth rate of non-agricultural value added increases total GDP growth by 0.85 percentage points. Yet, in comparing these effects it is essential to consider that agriculture comprised only 29% of total GDP during the simulation period, while non-agriculture comprised 71%. Thus, most of non-agriculture's contribution in increased economic growth is the result of its

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direct contribution as a share of GDP. The indirect effects of agriculture's contribution to increased growth are substantially greater relative to its share in the economy than are those of non-agriculture. This is due to agriculture's higher growth multiplier.

The simulation model also permits a crude analysis of the effect of agricultural price policy on economic growth. A one-time 10% increase in the rural-urban terms of trade (e.g., the price of agricultural products relative to the price of non-agricultural products) results in a net long-run increase in total GDP of nearly 4.7 million (1982) pounds. This suggests that greater price incentives to agriculture stimulate the entire Kenyan economy. Yet, the magnitude of this increase is quite small relative to the size of the economy.

This report's conceptual additions to the literature on agriculture's role in economic growth come through the identification of various non-market mechanisms by which agriculture contributes indirectly to growth. Previous literature concentrates on a range of market-based mechanisms through which agriculture contributes to growth. One set of linkages, associated with the work of Lewis, focusses on the process through which agricultural growth releases both labor and capital for employment in non-agriculture.[1] Our model presents this process as a function of agricultural productivity, among other things.

In their own work, Johnston and Mellor built upon Lewis, expanding the list of agricultural growth linkages to include other market-based effects. In addition to these

[1] Lewis (1954)

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Lewis-type linkages, Johnston and Mellor argued that agriculture also contributes to growth by providing food for domestic consumption (a wage good), enlarging the market for domestic non-agricultural production, and earning foreign exchange. The Johnston-Mellor linkages essentially operate through input and output markets. The empirical literature on regional growth linkages lies in this tradition, and is essentially an implementation of the Johnston-Mellor list.

To these sets of market-based linkages, the present study adds a short list of non-market-based linkages. One such non-market linkage comes through learning by doing by both government and industry. Governments' first challenge is often simply to feed their people. The skills learned in managing agricultural development eventually spill over into management of the rest of the economy. The model also stipulates that economic stability both promotes agricultural productivity and enhances the conditions necessary for agricultural productivity to contribute to non-agricultural productivity. In particular, greater economic stability has been shown to increase capital productivity.

A further non-market agricultural linkage comes from the greater efficiency of household decision making. Asian experience suggests that shifting control of resources towards rural households improves the efficiency of resource allocation and provides an important source of output growth. A final non-market linkage derives from switching investments from low to high productivity. The widely observed phenomenon of urban bias tends to distort investment patterns in favor of urban areas. The result is that too little capital is invested in raising rural productivity, and the marginal productivity of capital in the two sectors diverges widely. (The large disparity in the growth

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multipliers from public investments in agriculture and non-agriculture in Kenya cited above is symptomatic of this problem.) Investors could at least temporarily exploit this disequilibrium by shifting investment to agriculture, thereby contributing to more efficient resource allocation.

This report takes only the first steps towards measuring these impacts. The difficulties come, in part, from the lack of viable measures for some of these influences. Yet, further difficulties are posed by the focus of this study on a single case study country. The nature of several of these effects is such that statistical identification may only be possible in a cross-section data set.

The Kenya case does, however, permit several initial measurements of these effects. In particular, this study presents evidence that agricultural productivity growth contributes to non-agricultural productivity growth in Kenya. Based on the estimation of agricultural and non-agricultural production functions, the preliminary results suggest that agricultural productivity growth accounts for up to one-fifth of the growth rate of non-agricultural productivity in Kenya. Further, economic instability accounts (negatively) for an additional 7% of non-agricultural productivity growth. Thus, agricultural productivity and macroeconomic instability together explain up to one-third of the growth in non-agricultural productivity in Kenya.

This linkage represents a potentially large component of agriculture's indirect contributions to economic growth. Though less detailed than one would like, these additional results fill in some of the gaps in our simulation model, and do so in a manner that is consistent with the predictions of our conceptual model.

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The basic policy implication of this study is that agriculture must remain at the core of economic development strategies in most poor countries. The conceptual model presented in this study argues that market failures have led to the undervaluation of agriculture in many countries. This undervaluation has led to under-investment in agriculture. The model further argues, however, that agriculture -- and agricultural productivity in particular -- has a central role to play in supporting and sustaining economic growth. This report demonstrates that agricultural growth linkages have a sound foundation in both theory and practice.

While further research is necessary to measure the full effects of these linkages, it is not necessary to await further research for governments to justify a much more positive 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 -- the stage most common across Sub-Saharan Africa today -- even the preliminary evidence presented in this report suggests that stimulating agricultural growth will have large economy-wide effects.

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Chapter 1. Introduction

This study takes a new look at an old topic: agriculture's role in economic growth. The debate on this subject is centuries old; yet, the realization that agriculture is central to the growth process in poor countries is relatively recent. The discussion in recent decades has been shaped by Johnston and Mellor's classic article, in which they identify five types of inter-sectoral linkages that highlight agriculture's role in economic growth.[1] In their view, agriculture's forward and backward linkages, operating through both production and consumption, include: 1) providing food for domestic consumption, 2) releasing labor for industrial employment, 3) enlarging the market for domestic industrial output, 4) increasing the supply of domestic savings, and 5) earning foreign exchange.

Recent empirical work on the regional level has specifically measured the Johnston-Mellor linkages, finding substantial growth multipliers from exogenous increases in agricultural income.[2] In general, these studies have found the growth multipliers from agriculture to exceed those from non-agriculture. Indeed, the most recent additions to this literature have found agricultural growth multipliers in Sub-Saharan Africa to be substantially larger than previously thought.[3]

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[1] Johnston and Mellor (1961)

[2] This literature, much of it by Hazell, Haggblade, and others is discussed in the following chapters.

[3] Delgado, et.al. (1994)

The sheer size of agriculture in most African economies suggests that strategies designed to promote the early stages of economic growth cannot ignore agriculture. For a typical country in Sub-Saharan Africa, agriculture accounts for 33% of GDP, employs 70% of the workforce, and provides roughly 40% of total export revenue. In Kenya, the primary focus of the empirical sections of this study, agriculture (on average from 1972-91) comprised 30% of the economy, employed 45% of the workforce and earned over 54% of the country's foreign exchange. The simplest growth accounting framework would measure agriculture's "direct" contribution to economic growth as agriculture's growth rate weighted by its share in GDP. Given these figures, its direct contribution alone should make agriculture a major consideration in economic growth strategies.

It has become a standard tenet of development economics that agriculture's share in GDP *declines* as economies grow. Accordingly, agriculture's direct contribution to economic growth must also decline as economies grow. Yet, for most poor countries, this growth process can only be sustained by substantial and continued increases in agricultural *productivity*.[4] In other words, agriculture's direct contribution to economic growth can decline only if its *indirect* contribution increases. Part of the contribution of the present study is to demonstrate that increases in agricultural productivity are a central component of agriculture's indirect contributions to economic growth. The role of agricultural productivity in contributing to non-agricultural growth,

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[4] See Timmer (1988) for a detailed discussion of this point in the context of the agricultural transformation.

and thus indirectly to economic growth, both complements and adds to the Johnston-Mellor list of linkages.

The conceptual model presented in this study describes a process in which agriculture contributes to economic growth through several means, including both market-based linkages and non-market-based linkages. Agriculture is a source of both labor and capital for non-agricultural production. These "Lewis"-type linkages through factor markets are complemented by the Johnston-Mellor linkages, which operate primarily through input and output markets. To these standard components of the model, the present study adds a set of *non-market* linkages which enhance agricultural productivity and other determinants of non-agricultural productivity. These non-market linkages pertain to concepts of learning by doing, economic stability, the efficiency of rural decision-making, and the effects of urban bias. Using Kenya as a case study, the empirical sections of the study take the first steps towards validating this broader conceptual model.

The following chapter presents the conceptual model in detail, placing it in the context of existing literature. Chapter Three presents a simple two-sector econometric simulation model of the Kenyan economy. This model permits the calculation of agricultural and non-agricultural growth multipliers on the national level. In this regard, the model complements the more detailed regional growth linkage models, building indirectly on their evidence to assess the national income implications of agricultural growth. That simulation model, however, lacks the detail necessary to validate the specific elements of the conceptual model presented in Chapter Two. Chapter Four

takes a step towards measuring the specific non-market linkages through which we posit that agricultural productivity contributes to non-agricultural productivity, and thus indirectly to economic growth. The final chapter identifies areas in which the present work is incomplete, suggests avenues for future research, and assesses policy implications.

Chapter 2. Agriculture and Economic Growth: Conceptual Issues

Alternative Approaches to Growth Linkage Modelling

Growth in agricultural output can fuel growth in the non-agricultural economy through a variety of mechanisms, some direct and some indirect.[1] Because agriculture's share of GDP declines steadily as part of the structural transformation accompanying economic growth, resources from the agricultural sector are released for use in higher productivity activities in the industrial or service sectors. These resources are used much more efficiently, and contribute more to economic growth, if they are freed from agriculture through rapid productivity growth, and if they are attracted to the non-agricultural sector by dynamic demand for factors of production. The alternative, that labor is forced out of agriculture because of extremely low and insecure incomes, can contribute to serious problems of poverty in both rural areas and urban slums.

Interaction between the agricultural and non-agricultural sectors also takes place in input and output markets. Most countries produce most of their own food, and so the agricultural sector is an important, and often crucial, factor in food security at the aggregate level. In the early stages of industrialization, much of factory output depends on agricultural raw materials, and domestic supplies usually dominate because of high transportation costs for raw materials, high spoilage rates for unprocessed food

[1] The literature on this topic is enormous. Johnston and Mellor (1961) provide an early summary in an article that has become a classic for its careful analysis of the need for a balanced growth strategy that includes agriculture. A recent review of the topic and literature is in Timmer (1992).

commodities, and the need for timely deliveries to maintain efficient production levels in processing plants.

Finally, even when the agricultural sector contributes a relatively small share of GDP, the size of the population living in rural areas and partially dependent on agriculture for its income often remains much larger. There are two consequences of the large rural populations in these countries. First, their sheer size makes them an important market for manufactured goods, especially for the low-quality goods produced in factories that have not learned to meet export standards. Second, when the share of GDP generated in agriculture is substantially smaller than the share of the population living in rural areas, rural poverty can become a serious problem. This poverty is important in human terms and, because the numbers of people are substantial, rural poverty can also generate vocal political movements that might slow economic growth.

The linkages between agricultural growth and growth in the non-agricultural economy can be modeled and estimated at three basic levels: the local or regional economy, the national economy, or in cross-country comparative perspective. The regional approach typically uses household data on incomes and consumption coupled to a regional Social Accounting Matrix (SAM) to examine the impact of exogenous changes in agricultural productivity on incomes in non-agricultural households.[2]

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[2] See Bell, Hazell, and Slade (1982), for an analysis of multipliers generated by increased rice production from the Muda Scheme in Malaysia, Haggblade, Hazell & Brown (1989) for a survey of linkages in Africa, and Delgado, Hazell, et al. (1994), for a report on recent empirical studies in several African countries.

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The multipliers linking increases in agricultural productivity to non-agricultural activities tend to be a function of the tradability of food commodities, rural infrastructure, density of population, and the nature of technological change, but they are significantly greater than one. At least as measured from within the constraints of the regional models used in this type of analysis, agriculture is a source of growth for the non-agricultural economy.[3]

At the aggregate level, two broad categories of linkages cause an interaction between agricultural development and development of the overall economy, including the industrial sector. First are the traditional market-mediated linkages that form the core of economic analysis of the role of agriculture in economic development: providing labor for an industrial workforce, food for an expanding population with higher incomes, savings for industrial investments, markets for industrial output, export earnings to pay for imported capital goods, and raw materials for agro-processing industries.[4]

In addition, however, a second set of linkages is not well mediated by market forces even when markets are working well. Sensitive interventions by government are required in these circumstances if agriculture is to play an appropriate and stimulative role in support of the rest of the economy. [5] Several mechanisms that generate these non-market linkages are investigated in this report, including mechanisms that link agricultural growth to growth in total factor productivity in the non-agricultural sector,

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[3]Delgado, et al. (1994)

[4]Johnston and Mellor (1961); Timmer (1992); Delgado, Hazell, et al. (1994)

[5]Timmer (1993)

price stability to increased efficiency in investment decisions, and more rapid resource mobilization for investments in public goods, such as rural infrastructure.

So far, measuring these indirect and roundabout linkages at the aggregate level has relied on "Mundlak-type", multi-sectoral simulation models that trace the dynamic interaction of exogenous changes in agricultural productivity with the rest of the economy. By necessity, building these models is a country-specific task that is highly data intensive and requires substantial institutional knowledge of each country on the part of the researcher. The results from the few tests of this approach, however, have been startling. Long-run agricultural supply response turns out to be much higher than previously estimated on the basis of single commodity models, and positive linkages to the overall growth process from agricultural growth are quite large.[6] In the work reported here for Kenya, for example, the econometrically-estimated simulation model shows that an exogenous shift in agricultural output raises national income 1.64 times as much as the shift, whereas an exogenous shift in industrial output has a multiplier of just 1.23.

The third approach to measuring the impact of agriculture on economic growth is to extend the recent literature on theories of endogenous growth to include the potential contribution of agriculture.[7] This approach is just beginning to be tested empirically, but

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[6]Mundlak (1982, 1989)

[7] An excellent review of the origins of this literature is in the Winter, 1994, issue of the *Journal of Economic Perspectives*. This literature stresses the role of externalities, increasing returns, knowledge and technological research, and the potential impact of public policy on the economic environment for investment, including investment in public goods Much of the cross-country empirical analysis was stimulated by Barro and is summarized in the forthcoming textbook by Barro and Sala-i-Martin, *Economic Growth.*

early results are reported by Hwa and Schiff and Valdés.[8] The latter authors, for example, present several summary tables that are re-assembled in Table 2-1.

Table 2-1 Agricultural Taxation and Economic Growth

Total Taxation of Agriculture	Nominal Protection Coefficient		Annual Growth Rate of Agriculture	Annual Growth Rate of GDP
Very High	-51.6			0.033
		-46.2	0.027	
High	-36.4			0.051
Medium	-15.8			0.053
		-8.3	0.052	
Low	10.4			0.065

Source: Schiff and Valdés, 1992, pp. 204 and 206.

The data, based on detailed analysis of direct and indirect taxation of agricultural commodities in 18 countries, show that in countries with high taxation of agriculture, the result is a low rate of growth in agricultural output (2.7 percent per year on average). Also, these countries experience low growth in GDP as well (4.2 percent is the average for countries with "very high" and "high" rates of agricultural taxation). Lower taxation of agriculture, or even modest protection, leads to more rapid agricultural growth (5.2 percent per year) and to more rapid growth in GDP (5.9 percent per year for the average).

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[8]Hwa (1988), Schiff and Valdés (1992)

If these results can be generalized, they suggest that agricultural growth rates can be nearly doubled by ending heavy taxation, direct and indirect, of the sector. In turn, the growth rate of GDP will increase by about two percentage points per year, a relative increase in the aggregate growth rate of 40 percent (and probably a doubling of the per capita growth rate in GDP). Part of this increase will be due to the direct impact on the non-agricultural economy of more efficient and growth-oriented macro and trade policies, such as a correctly-valued exchange rate and less industrial protection, and not because the increase in agricultural output stimulated increases in non-agricultural output. Yet, the evidence does suggest that the agricultural sector also contributes directly to the increase in non-agricultural output.[9]

Do Markets Value the Indirect Contributions of Agriculture to Economic Growth?

If growth in agricultural productivity stimulates growth in the rest of the economy through a variety of indirect and roundabout linkages, it is important to know whether the value of agricultural output as reflected in market prices encompasses the full value of these multipliers. If not, agricultural producers and government policy makers involved in setting priorities for public investments will not receive appropriate signals about how much to produce.

The market value of agricultural output has three distinct dimensions: the relative value of the sector in the economy; the market price for individual agricultural

[9]Schiff and Valdés (1992)

commodities; and, the degree of instability in these valuations. Since World War II, the signal from each of these three dimensions has been consistent with longstanding patterns of economic performance.[10] First, the value of agriculture in relation to the value of the entire economy has declined as countries have become richer. That is, the share of agriculture in GDP declines as incomes rise. Second, the unit value of agricultural commodities in world markets has declined in real terms. The rate of decline is different for different commodities, but the overall trend is pervasive and significant. Third, there is great instability in the prices of many agricultural commodities, especially for the food grains that are the staple foodstuff of the poor, and for many of the export commodities produced by low-income farmers.

Although none of these signals from agricultural markets is new, the postwar data are still startling in the clarity of their message. Table 2-2 illustrates the relationship between the share of agriculture in the Gross Domestic Product (GDP) of a country and its level of income as defined by the World Bank.

Table 2-2. Income Growth and the Share of Agriculture

World Bank	*Income per capita*		*Share of Agriculture in GDP*	
Income Category:	1965	1990	1965	1990
Low	170	350	41	31
Low-Middle	1,055	1,530	22	17
High-Middle	1,710	3,410	16	9
High	10,830	19,590	5	2.5

Note: Data from World Bank, *World Development Report, 1992.* The figures on income per capita are in 1990 U.S. dollars and the 1965 figures are calculated from the growth rates shown in the *World Development Report.*

[10]Chenery and Syrquin (1975)

The declining share of agriculture during the process of economic growth is one of the best documented relationships in all of economics. As shown in Table 2-2, it holds for countries over extended periods of time and across countries at a point in time (with due allowance for differences in natural resource bases). The declining importance of agriculture is uniform and pervasive, a tendency obviously driven by powerful forces inherent in the development process, whether in socialist or capitalist countries, Asian, Latin American, or African, currently developed or still poor.

At least two mechanisms, now relatively well understood and documented, account for this process of structural transformation. Engel's Law alone, in a closed economy with constant prices, explains a declining share for agriculture (and low farm incomes unless some farmers leave agriculture) no matter how fast the growth of the agricultural sector itself. Because growth is led by demand patterns in market economies, a less-than-unitary income elasticity for the products of the agricultural sector guarantees that gross value of sales by farmers will grow less rapidly than gross domestic product. If agricultural output fails to grow rapidly enough, rising prices might actually garner farmers a higher share of consumers' expenditures. But this would reflect lower real incomes, not the result of economic growth.

If the terms of trade are not to rise in favor of agriculture because of a shortage of food, farm productivity must rise. The second factor that explains the structural transformation is the rapid growth in agricultural productivity, measured by output per laborer or output per hectare, in all the successfully developed countries. Technical change in agriculture has proceeded at such a pace that the long-run terms of trade

declined for farm products. Lower prices thus exacerbate the sluggish growth in demand due to low income elasticities; the combination puts pressure on agricultural resources to move out of farming and into the more rapidly growing sectors of the economy.

The pace of the price decline may have accelerated since the world food crisis in the early 1970s, thus exacerbating the declining share of agriculture in the structure of developing countries. Statistical analysis of the data on structural change in Table 2-2 reveals that the share of agriculture in the four categories of countries was roughly 12 percent lower in 1990 than would be predicted by the relationship between incomes per capita and agricultural shares in 1965. If agricultural prices in general had been at the same real level as in 1965, the share of agriculture in the economies of low income countries would have been 35 percent instead of the 31 percent recorded.[11] This calculation does not recognize any additional production that might have been induced by higher agricultural prices, and it thus is very conservative.

Taken together -- the declining share of agriculture in GDP, declining rural-urban terms of trade, and highly unstable prices for agricultural commodities in world markets -- these three factors confuse policy makers with respect to an appropriate strategy for the agricultural sector. The declining share of agriculture during economic development might suggest to some that the sector is not important, and that care must be taken to keep it from expanding too much. Reinforcing this perspective, the decline in the real

[11]The calculation assumes that the relationship between income levels and agricultural share that held in 1965 can be extrapolated to income levels in 1990. The per capita income of "Low Income" countries in 1990--$350 per year--is then applied to this relationship, with the result that agricultural share would have been 35 percent.

prices of important agricultural commodities makes investments in raising production capacity increasingly unattractive. Investment in irrigation or an agricultural research station may look financially viable if the rice produced is valued at $300 per metric ton, but the investments are likely to be socially unprofitable if the market value is expected to fall gradually to only $150 per ton during the life of the project. Uncertainty about the price that is caused by instability in world markets further dampens investment prospects. Faced with an array of competing investments and an historical picture of the structural transformation that suggests industrialization is the path to economic development, many policy makers will find it quite rational to follow a strategy that commits few resources to the agricultural sector.

Such a strategy not only undervalues agriculture, it also misses the contribution to faster economic growth that rising agricultural productivity can provide. Reducing urban bias by stimulating agricultural production, especially in the early stages of the development process, raises the efficiency of resource allocation and increases the overall rate of economic growth. With a properly specified econometric model, it should be possible to test this hypothesis, and Chapters Three and Four present alternative tests in the Kenyan context.

Unfortunately, when agricultural commodities are produced in poor countries attempting to stimulate the process of economic growth, world markets fail to reflect the full social value of producing these commodities. When these countries use the border price paradigm to value their most important agricultural output, and thus follow the advice of donors and economists, they eliminate the price biases typically imposed by

the political process. Yet, agriculture remains undervalued by market prices and fails to provide optimal stimulation to economic growth if all investment decisions, public and private, are based on these prices.

There are four reasons agricultural commodity markets fail to provide developing countries appropriate signals for valuing their agricultural sectors. First, their prices do not reflect the importance to countries of maintaining food security and the appropriate balance between domestic and foreign supplies of food. The easy availability of food aid and depressed grain prices in world markets -- largely caused by explicit export subsidies provided by the European Community and the United States -- make this problem very difficult.

Second, the special role of the agricultural sector in alleviating poverty is ignored in the market value of agriculture, despite the large share of poverty in developing countries found (or originating) in rural areas. In view of the argument by Dasgupta that rural poverty is linked to excessive growth of population, a case can be made that stimulating agricultural production also contributes directly to protecting the rural resource base and to slowing population growth.[12]

Third, nascent governments need to learn how to make a market economy work, and the lessons achieved through "learning by doing" in the rural economy are particularly relevant[13]. The combination of using markets to reach highly decentralized

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[12]Dasgupta (1993), and Timmer (1994)

[13]Timmer (1992a)

farmers and the necessity for public investments in rural infrastructure if the markets are to work efficiently can be generalized to other sectors of the economy as well.

Fourth, market prices for agricultural commodities undervalue the indirect effects of agricultural growth on providing resources for economy-wide investment as well as its roundabout impact on increasing total factor productivity for the entire economy. Agricultural growth stimulates the entire growth process in ways not reflected adequately in market prices.

If Lipton is right about the pervasive urban bias in government policies in developing countries, and if markets also undervalue the contribution of agriculture to the process of economic growth, the empirical record should show a strong positive relationship between the rate of economic growth and growth in the rural economy.[14] In its most basic form, this relationship is very clear. Figure 2-1 shows, for example, a significant positive relationship between growth in the agricultural sector and growth in the nonagricultural sector between 1965 and 1980 for a sample of 40 representative countries. This clear and positive association between growth in the two sectors does not, of course, show causation. Good macroeconomic policy, for example, could cause both sectors to grow independently. The rationale proposed here for why markets undervalue agriculture argues that there is a causal connection. To demonstrate this, it is necessary to model a set of linkages between agriculture and economic growth that can be specified and estimated. The logic of such a model involves several steps.

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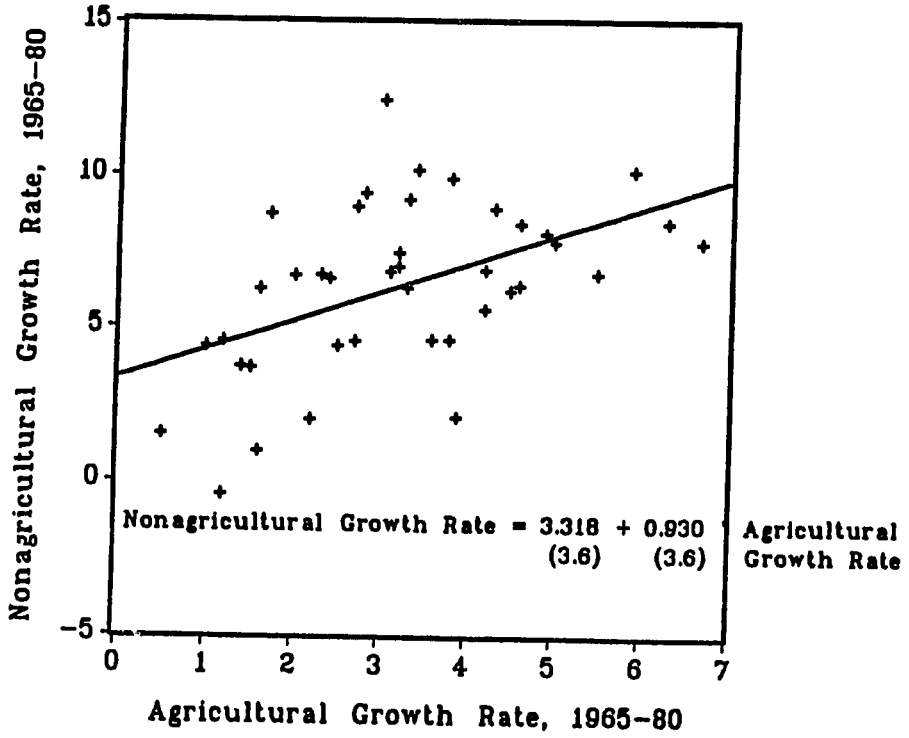
[14]Lipton (1977, 1993)

FIGURE 2-1 Relationship between Agricultural and Nonagricultural Growth



An Expanded Conceptual Model of Agricultural Growth Linkages

It has been known since the work of Solow and Denison that differential rates of economic growth are not explained entirely by different rates of growth in labor and capital.[15] An additional element is the productivity with which the labor and capital are used, and differences in factor productivity are very substantial. They set apart the rapidly growing countries of East and Southeast Asia from the rest of the developing world. Factor productivity is growing rapidly in these countries, but it is falling in Africa and Latin America.[16]

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[15]Solow (1956), Denison (1967)

[16]World Bank (1991)

In principle, many causes of differences in productivity growth might be identified. Empirically, three robust contributors include the positive effects of a competitive cost structure; the negative effects from instability; and the positive effects of growth in agricultural productivity.[17] As discussed below, cost structure in this context represents a combination of several related, but distinct, factors: capacity utilization, competitive pressures, and technology. In the presence of fixed capital, higher capacity utilization can improve the efficiency of resource use, and thus contribute to non-agricultural TFP. These effects can be reinforced if the domestic non-agricultural economy is challenged by external competitive pressures. High-capacity utilization and competitive pressures together can enhance the direct effects of technical change on non-agricultural productivity.

Most empirical tests have used the growth rate of exports or other measures of "outward orientation" as a proxy for competitive pressures that would keep costs low, the rate of inflation (or variance in the rate) as a measure of instability, and the rate of growth of agricultural GDP to measure rural linkages to the overall growth process.[18]

The specification of all three independent variables has serious problems. The factors keeping costs competitive have many components, and even "openness," just one of these components, is difficult to define and measure. Instability is reflected in inflation, to be sure but instability also results from variance in export earnings or from highly unstable food prices. The agricultural growth rate should not be used as a

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[17] Hwa (1988)

[18] Hwa (1988); Block (1991); Dawe (1993)

variable explaining aggregate growth in GDP because it is a direct component of that aggregate growth. Even specifications that explain non-agricultural GDP using agricultural GDP as an independent variable risk serious bias if agricultural growth simply serves as a proxy for an excluded variable that would measure the economic policy environment. Specifications that attempt to correct these problems, although still imperfect, continue to indicate a very robust effect of agriculture on the rest of the economy.

Several linkages can cause growth in agriculture to contribute directly to higher living standards for rural people while also stimulating growth in productivity for the entire economy in an indirect and roundabout fashion (See Figure 2-2). Each linkage alone should cause an increase in the efficiency of resource allocation as growth in the agricultural sector accelerates. In combination, these linkages should translate faster agricultural growth into measurably faster economic growth in aggregate, after controlling for the direct contribution of the agricultural sector to growth in GDP itself.

Figure 2-2 illustrates three sets of indirect and roundabout linkages that connect the agricultural and non-agricultural sectors:

(1) the "Lewis Linkages" that provide the non-agricultural sector with labor and capital from the agricultural sector. These linkages work primarily through factor markets, but there is no suggestion that these markets work perfectly in such a dualistic setting. Indeed, Chenery and Sryquin argue that a major source of economic growth is

Figure 2-2
Agricultural Growth Linkages

Direct:

$$\dot{Y} = \omega_{ag} * \dot{Y}_{ag} + \omega_{nag} * \dot{Y}_{nag}$$

"Lewis Linkages"

$$L_{nag} = g[L_{nag}(t-1),\ \lambda_{ag}(t-1);\ Y_{ag}/L_{ag}(t-1)]$$

$$K_{nag} = g[\omega_{ag} * Y_{ag}(t-1),\ \cdots]$$

Indirect:

$$Y_{nag} = f(\lambda_{nag},\ L_{nag},\ K_{nag})$$

$$\lambda_{nag} = g[\textit{Cost Competitiveness};\ \textit{Stability};\ \textit{Agricultural Productivity}\ (\lambda_{ag})\ ]$$

Roundabout:

"Johnston - Mellor Linkages"

- Earn Foreign Exchange
- Market for Industrial Output
- Supply Raw Materials to Industry
- Provide Food for Industrial Sector

"Timmer Linkages"

- Learning by Doing
- Food Security
- Efficiency of Rural Decision Making
- Reducing Urban Bias
- Labor Productivity and Nutrition

where: Y = value added, L = labor, K = capital, ω = sectoral share in GDP, and λ = total factor productivity

"Lewis Linkages" speed factor accumulation for industrial sector (must have higher productivity there or it cannot be a source of growth)

"Johnston - Mellor Linkages" operate primarily through input-output relationships (these are not a source of growth if all input and output markets function perfectly -- need "bottlenecks" or "constraints" on supply or demand for these linkages to stimulate faster growth in non-agricultural economy as agricultural productivity rises).

"Timmer Linkages" are driven explicitly by the types of externalities and market failures that provide the analytical rationale to endogenous growth theory.

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the transfer of low-productivity labor from the rural to the urban sector.[19] If labor markets worked perfectly, there would be few productivity gains from this structural transfer. Similarly, forced extraction of capital from agriculture through heavy taxation or discriminatory pricing will only contribute to economic growth if capital productivity is measurably higher outside of agriculture than within the sector, and capital markets do not correct the imbalance;

(2) the "Johnston-Mellor Linkages" that allow a set of market-mediated, input-output interactions between the two sectors based on agriculture supplying raw materials to industry, food for industrial workers, markets for industrial output, and the foreign exchange needed to import capital goods. Again, there is no suggestion that these linkages require perfect markets to operate. However, it is difficult to see any significance for policy or economic growth of the linkages unless some of the markets that serve these linkages are operating imperfectly, that is, they face constraints and bottlenecks not immediately reflected in market prices; and,

(3) the "Timmer Linkages" that focus on a set of nebulous and hard-to-measure connections between growth in agricultural productivity and growth in the rest of the economy. These linkages grow explicitly out of market failures and, if they are quantitatively important, will require government interventions for the growth process to proceed as rapidly as possible. In the context of these linkages, the contribution of agricultural growth to productivity growth in the non-agricultural economy stems from at least five sources: the contribution to learning by doing, both by government and firms;

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[19]Chenery and Syrquin (1975)

to food security and political stability; to greater efficiency in decision making as rural enterprises claim a larger share of output; to higher productivity of industrial capital as urban bias is reduced; and to higher productivity of labor as nutritional standards are improved.

The roundabout linkages modelled in Figure 2-2 are assumed to influence growth in the non-agricultural sector through their impact on total factory productivity (TFP). Both the Johnston-Mellor linkages and the Timmer linkages contribute to all three general factors thought to influence TFP growth in the non-agricultural sector: cost competitiveness, stability, and agricultural productivity. Although not all of these linkages can be measured with data currently available, it is important to spell out the basic logic of the connections. Table 2-3 shows the main elements in the argument.

Table 2-3 Indirect and Roundabout Agricultural Growth Linkages

TFPnag = f[Cost Structure; Stability; Agricultural Productivity]

A. Cost Structure
   1. Capacity Utilization
      - raw materials
      - foreign exchange for imported inputs
      - labor supply
   2. Competitive Pressures
      - "openness" of economy
      - domestic regulations
      - size of economy (small is less competitive)
   3. Technology
      - research and development
      - extension
      - education
      - exogenous (time trend)

B. Stability
   1. Macro Stability
      - inflation or variance in inflation
      - export instability
   2. Food Price Instability
      - macro effects
      - political economy effects

C. Agricultural Productivity
   1. Learning by Doing
      - government
      - industry with captive domestic market
   2. Food Security and Reduced Price Instability
   3. Efficiency of Rural Decision Making
      - low costs of household resources (in non-agricultural activities such as trading and small industry)
      - uncounted investments in rural enterprises
   4. Effects on Capital Productivity of Reducing Urban Bias
      - shifting investments from low productivity in the urban economy to high productivity in the rural economy
   5. Effects on Labor Productivity of Improved Nutrition

Growth in agricultural productivity influences TFP in non-agriculture as a direct contributor to the function shown in Figure 2-2 -- this influence is through the "Timmer Linkages." Yet, growth in agricultural productivity also influences TFP in non-

agriculture by contributing to a competitive cost structure and by stabilizing the economy. Both the "Johnston-Mellor Linkages" and the "Timmer Linkages" contribute to this indirect influence.

Table 2-3 lists the main factors that influence each of the three basic ingredients in TFP for non-agriculture--cost structure, stability, and agricultural productivity (directly). The list is long and purposefully inclusive at this stage even though few of the variables are empirically measurable. Cost structure, for instance, is influenced by capacity utilization, by competitive pressures, and by level of technology, and each of these factors depends in turn on a variety of specific contributors. For example, capacity utilization in the industrial sector is influenced by availability of raw materials, access to foreign exchange to import intermediate inputs, and by adequacy of the labor supply. Agricultural growth and productivity are essential for the availability of each of these factors.

Stability of the economy is influenced by the rate of inflation, or the variance in that rate, by the degree of export instability and the importance of exports in the overall economy, and by instability in food prices. The agricultural sector can contribute to greater or lesser instability in each of these three measures, and the overall impact is likely to be additive.

Perhaps the most difficult linkage to specify and identify is the direct effect of agricultural productivity on TFP in non-agriculture. To economists, linkages that work through factor markets or input and output markets have a conceptual foundation that is easy to understand even if the linkages themselves are hard to measure. Both the

Lewis linkages and the Johnston-Mellor linkages fall in this category, and they have been widely accepted and measured by economists, if not always recognized by policy makers.

Including agricultural productivity directly in the function explaining TFP in non-agriculture invokes a different conceptual framework that extends beyond the neo-classical growth model that is implicit in the market-mediated linkages associated with Lewis and Johnston-Mellor.[20] The intellectual foundation for this framework grows out of endogenous growth theory, which recognizes the importance of externalities, scale effects, learning by doing, hysteresis, and policy-induced shifts in expectations by investors as central to the process of economic growth. None of these factors has been easy to model and measure in ways that make econometric estimation feasible, but that does not mean they are unimportant either conceptually or empirically.

The next two chapters make a preliminary, and highly tentative, effort to test the importance of these roundabout influences of growth in agricultural productivity on the overall process of economic growth. The tests focus on Kenya, partly because a detailed case study was essential at this stage of the empirical work and partly because Kenya has been one of the most successful countries in Sub-Saharan Africa in raising agricultural productivity. If Africa is the most important region of the world where agriculture remains important to the growth process, Kenya is a leading example, at least historically, of relatively successful growth in agriculture. Most of the original intuition suggesting the roundabout linkages between agricultural productivity and TFP

[20]This approach is tested with Kenyan data in Chapter 4.

in non-agriculture originated in the context of rapid economic growth in Asia. If they turn out to be quantitatively important in Kenya as well, the demonstrated importance of agriculture to the Asian growth record is likely to have important lessons for Africa[21]

[21]Timmer (1993b)

Chapter 3. A Simulation Model of Kenya's Economic Growth

This chapter examines the relative contributions of agriculture and non-agriculture to Kenya's economic growth. The previous chapter presented a broad conceptual model in which agriculture contributes to economic growth, not only because agriculture is a large share of the economy, but because agricultural growth also stimulates non-agricultural growth. Agriculture's contribution to growth is thus both direct and indirect.

The growth linkages literature has focussed almost exclusively on the regional level, using household-level data to measure the forward and backward linkages arising from both production and consumption in the agricultural sector. This literature provides a firm empirical foundation for the Johnston-Mellor linkages between agriculture and non-agriculture. The use of household-level data permits the specific measurement of the various types of inter-sectoral linkages, the combined effects of which are summarized in a growth multiplier. The methodology employed in those studies, however, limits the interpretation of their multipliers to the regional level. These multipliers cannot be applied directly to the level of national income because the assumptions necessary for their calculation in those studies do not hold at the national level.[1]

[1] The chief culprit in this regard is the assumption of semi-input-output models of a perfectly elastic supply of non-tradables. Moreover, the studies tend to be based on regional data, which may not represent an entire country.

The model presented below builds on the findings of those regional-level studies and complements their perspective: the growth linkage studies capture the richness of the local economies but their results do not apply directly to national income; the simulation model presented below measures agricultural growth multipliers at the national income level, but does not explicitly model the microeconomic linkages.

Model Specification[2]

The goal of this model is to replicate Kenya's economic growth from 1972-92 as a function of growth in two sectors (agriculture and non-agriculture) and the interaction between them. In other words, output growth in agriculture adds directly to Kenya's overall economic growth in proportion to the sector's share of GDP. Yet, by taking account of the intersectoral linkages between agriculture and non-agriculture, the model attempts in addition to measure agriculture's *indirect* contribution to overall economic growth through agriculture's contribution to growth in non-agriculture. Similarly, the model attempts to capture the feedbacks from non-agriculture to agriculture, thus providing a basis for comparing the relative contributions of each sector to overall growth.

The model is intended to be as simple as possible, and is thus limited to a level of aggregation that can barely begin to capture the full complexity and richness of the underlying processes. Its primary purpose is to measure the extent of the intersectoral

[2] The specification of this model is patterned after Rangarajan (1982), though the present model differs from Rangarajan's in several key respects The most critical difference is that agricultural value added is endogenous in the present model

linkages in the growth process, rather than to serve as a tool for detailed policy simulation. Data are drawn from the national accounts and related sources from the Government of Kenya. These data have been collected in historical time series in an extremely useful report by the Kenyan Ministry of Planning and National Development.[3] The disaggregation of agricultural and non-agricultural investment by public versus private sources is based on further research by that Ministry.[4]

As noted above, the first goal of the model is to replicate the actual historical paths of key macroeconomic and sectoral variables. Once a model is accepted as accurately describing what *did* happen, it can be used for various counterfactual experiments to assess what *would have* happened had particular conditions been different. The simulated time paths for the "key" variables (e.g., the endogenous variables) are determined within the model. These are estimated as functions of variables that are not simulated within the model (e.g., exogenous variables) and past values for the endogenous variables. Since the predicted value for a given endogenous variable depends on predicted values of other endogenous variables, the model itself consists of a system of inter-related equations each of which is used to predict the value of one endogenous variable. The present version of the model includes thirteen endogenous variables, and thirteen equations (which are presented in Table 3-1).

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[3] Short, Keyfitz, and Maundu (1994)

[4] Wilson (1993)

Table 3-1. Model Equations[5]

Identities:

(1) $YFACP = YA + YN$

(2) $YMKTP = YFACP + \overline{INDTXSUB}$

(3) $CONP = YMKTP - GI - \overline{GOV} - TDBAL$

(4) $YN = YC + YBK$

(5) $GI = GIA + GIN + \overline{GIAP} + \overline{GINP} + \overline{DELSTK}$

Production:

(6) $YC = f(\underset{+}{GIN_{t-1}}, \underset{+}{YA}, \underset{-}{RUTT_{t-1}}, \underset{+}{\overline{INDTXSUB}}, \underset{+}{\overline{GINP_{t-1}}})$

(7) $YBK = f(\underset{+}{YA_{t-2}}, \underset{+}{GIN_{t-1}}, \underset{-}{RUTT}, \underset{+}{\overline{GINP_{t-1}}}, \underset{-}{\overline{DROUGHT}}, \underset{+}{\overline{TOT}})$

(8) $YA = f(\underset{+}{RUTT_{t-2}}, \underset{+}{GIA_{t-3}}, \underset{+}{YN_{t-1}}, \underset{-}{\overline{DROUGHT}}, \underset{+}{\overline{GIAP_{t-3}}})$

(9) $TDBAL = f(\underset{+}{YA}, \underset{+}{YN}, \underset{-}{\overline{INDTXSUB}}, \underset{-}{\overline{TOT}})$

Investment:

(10) $GIA = f(\underset{+}{YA}, \underset{+}{\overline{KIMP}}, \underset{+}{YBK_{t-1}}, \underset{-}{\overline{INSTAB}}, \underset{+}{\overline{NER}})$

(11) $GIN = f(\underset{+}{YA}, \underset{+}{YN_{t-1}}, \underset{-}{\overline{INSTAB}}, \underset{+}{\overline{KIMP}})$

Prices:

(12) $RER = f(\underset{+}{\overline{NER}}, \underset{-}{\overline{GOVEXP}}, \underset{-}{\overline{TOT}})$

(13) $RUTT = f(\underset{+}{RER_{t-1}}, \underset{+}{\overline{CFBOOM}}, \underset{-}{YA})$

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[5] Variable names and definitions are included in Appendix 3-1. The actual estimates are summarized in Appendix 3-2.

The endogenous variables are on the left-hand side of the equations, and are determined in each case by the right-hand side variables. Among the right-hand side variables, the lagged endogenous variables are indicated with time subscripts and the exogenous variables have bars over them. The sign beneath each variable indicates the direction of its effect on the dependent variable. Several of the exogenous variables can be used as policy levers to perform counterfactual experiments with the model. There are two aspects of these equations to be described: the specification of the individual equations and the manner in which the individual equations relate to one another.

The model consists of five identities (equations (1) - (5)) and eight stochastic equations (equations (6) - (13)).[6] The identities impose certain relationships on the results that must always hold, and thus ensure that the simulations conform to balanced national accounts. Equation (1) describes the income side of the economy, stipulating that GDP (at factor prices) must always be the sum of agricultural GDP and non-agricultural GDP. In the national income accounts GDP at factor prices and GDP at market prices differ by indirect taxes and subsidies (which are excluded from GDP at factor prices). Equation (2) simply ensures that this relationship is always true in the model. The distinction is necessary because in the national accounts, the expenditure side of the economy is equated with GDP at market prices.

[6] The stochastic equations are estimated in first differences to minimize spurious correlations.

To be internally consistent, the model must ensure that national income equals national expenditures. Thus equation (2) connects the income side of the economy with the expenditure side, which is expressed in equation (3). Equation (3) is the familiar macroeconomic equation stating that national income equals the sum of private consumption, gross investment, government consumption, and the trade balance (e.g., Y=C+I+G+X-M). In order to ensure that the system balances (that income equals expenditure), private consumption is calculated as a residual in equation (3).

The remaining identities are definitions. Equation (4) divides non-agricultural GDP into two components: value added from the production of consumer goods and value added from the production of basic and capital goods. Equation (5) similarly defines gross fixed investment as the sum of private and public gross capital formation (investment) in agriculture and in non-agriculture (plus the change in capital stocks).

Equation (5) indicates that public sector investment in agriculture and non-agriculture is exogenous to the model. This raises an important issue for how the model is "closed." Macroeconomic balance imposes the restriction that public sector investment (a demand account) cannot be arbitrarily increased without a compensating decrease on the demand side of the economy. The most reasonable options would be either to fix total gross fixed investment (so that public investment would crowd out private investment one-for-one), or to subtract increases in public investment from private consumption as necessary to equate macroeconomic supply and demand. Given imperfections in Kenyan capital markets, full crowding out seems unreasonable.

The model thus compensates for increases in public investment with decreases in private consumption (which is already treated as a residual in equation (3)).

The remaining equations serve the purpose of predicting values for the endogenous variables. These equations can be grouped into blocks, each of which serves a distinct purpose within the model. Equations (6) - (9) determine output in each sector of the economy.[7] Investment supply by private sector sources is determined in equations (10) and (11). The final block (equations (12) and (13)) determines prices, which consist of the real exchange rate and the rural-urban terms of trade.[8] These equations are estimated in first differences by ordinary least squares regression. This is acceptable since the model is largely (though not purely) recursive.

The distinction noted above between agriculture's direct and indirect contributions to growth can be seen at this point. Figure 3-1 is a simplified flow chart highlighting the inter-sectoral linkages specified in the model.

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[7] Strictly speaking, the trade balance (TDBAL) is not a productive sector, and is included in the production block for convenience.

[8] As currently specified (as a function exclusively of exogenous variables), the real exchange rate is exogenous.

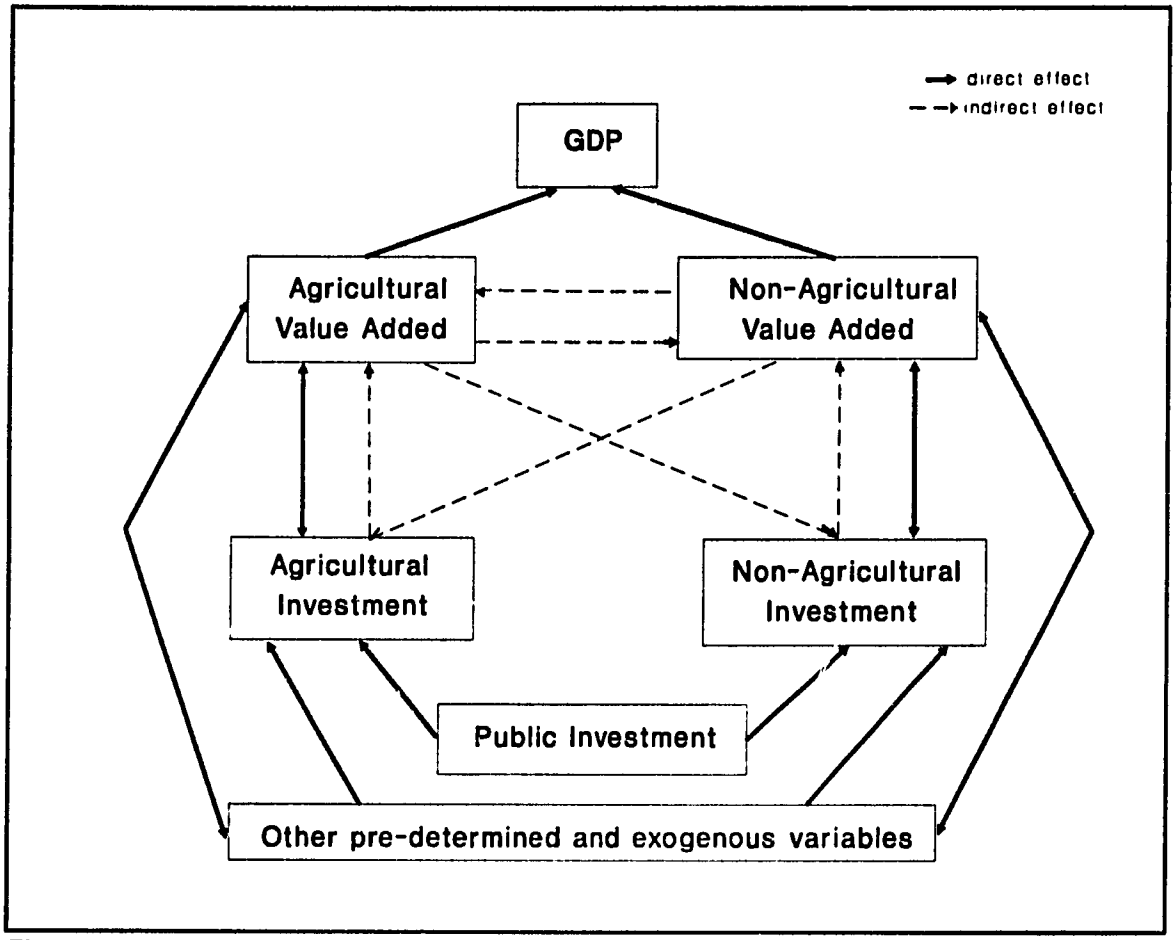

Figure 3-1 ***Simplified Flow Chart of Model's Intersectoral Linkages***

The critical distinction in this flow chart is between *direct* effects, indicated by solid arrows, and *indirect* effects, indicated by dashed arrows. Agriculture and non-agriculture sum directly to GDP. Value added in each sector is determined directly by sectoral investment and other pre-determined and exogenous variables (as specified in Table 3-1). Investment in each sector, in turn, is directly determined by own-sector value added, public investment, and other variables.[9]

[9] Note that for simplicity, Figure 3-1 omits the model's dynamic structure. The effects indicated by the arrows are not necessarily contemporaneous. The lag structure is specified in the equations of Table 3-1.

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The main goal of the model, however, is to measure the indirect contributions of each sector to economic growth. These effects are reflected by the dashed arrows in Figure 3-1. In particular, note that non-agricultural value added is an indirect function of agricultural value added. In addition, agricultural value added contributes to non-agricultural investment, which increases non-agricultural value added, and thus adds to agriculture's indirect contribution to growth. As indicated in Figure 3-1, these effects are specified symmetrically across sectors. Each sector thus has the same opportunities for indirect contributions to growth. The relative magnitudes of these effects are determined by the data. The following description of the remaining equations in Table 3-1 details the rationale for the specification of inter-sectoral linkages illustrated in Figure 3-1.

Equations (6) - (8) determine the value added on the supply side of the economy. These equations are somewhat ad hoc in that they are strictly neither supply nor demand equations, but contain elements of both. Equation (6) predicts the production of consumer goods as a function of lagged non-agricultural investment (both public and private in origin), current agricultural output, the rural-urban terms of trade, and indirect taxes and subsidies.

The presence of agricultural GDP in the supply function for consumer goods reflects two types of intersectoral linkages. Current work at AID/Kenya shows that a substantial portion of consumer goods production depends directly on agriculture for its raw materials. A recent survey of Kenya's micro-enterprise sector has shown that nearly one-half of these enterprises are based directly on agriculture (and the figure is

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closer to two-thirds if one includes forestry and textiles).[10] Abundant agricultural production would thus tend to reduce input costs in those industries and increase their output. At the same time, increased agricultural production raises the incomes of agricultural producers, thus increasing their effective demand for the outputs of consumer goods industries.

As in each of the output equations, the explanatory variables include lagged investment estimated separately for public and private sources. Both types of investment, along with agricultural output, positively affect consumer goods output. Indirect taxes and subsidies also enter positively, perhaps reflecting subsidy-induced consumption of consumer goods. The rural-urban terms of trade is the ratio of agricultural to non-agricultural prices. Considering food as a wage good for non-agricultural workers, the rural-urban terms of trade reflect the ratio between input costs and output prices facing non-agricultural employers. The rural-urban terms of trade thus enters negatively in equations (6) and (7).

Equation (7) describes the supply of value added in basic and capital goods industries, posited here to be a function of lagged public and private non-agricultural investment, the rural-urban terms of trade, lagged agricultural output, the foreign terms of trade, and drought. The inclusion of lagged agriculture in this equation is intended to reflect the increased demand for industrial products (including buildings and construction, electricity, and water) on the part of the agricultural sector following a

[10] These survey results are part of the forthcoming GEMINI Project report from USAID/Kenya.

good year. The dummy variable for drought reflects the general economic dislocation resulting from severe droughts in Kenya.

Equation (8) describes the value added in agriculture as a function of the lagged rural-urban terms of trade, lagged agricultural investment, lagged non-agricultural output, drought, and lagged public and private agricultural investment. Lagged non-agricultural output enters the agriculture equation to reflect the fact that non-agriculture both supplies inputs for agricultural production and purchases agricultural output. Both effects are enhanced by increased output in non-agriculture. The rural-urban terms of trade are the price incentives facing agricultural producers (e.g., the prices of what they sell relative to the prices of what they buy), and thus enter positively. The roles of drought and agricultural investment are straightforward.

Equation (9) predicts the trade balance, which is required to fill in the expenditure side of the economy as described in equation (3). The trade balance is estimated as a function of the foreign terms of trade, as well as agricultural and non-agricultural output, and indirect taxes (the vast majority of which are import and export duties). A fall in the foreign terms of trade improves the trade balance (exports increase relative to imports), as does increased output in agriculture and non-agriculture. Trade taxes are negatively related to the trade balance.

Equations (10) and (11) describe gross capital formation in agriculture and non-agriculture (originating in the private sector), respectively. Agricultural investment is estimated in equation (10) as a function of capital imports, lagged output in basic and capital goods industries, agricultural output, the nominal exchange rate, and a proxy for

general economic instability. Lagged output in basic goods attempts to capture investment across sectors resulting from increased output in non-agriculture. Agricultural output can also be re-invested in agriculture. The exchange rate is included to reflect the increased supply of agricultural capital sparked by improved opportunities for agricultural exports. Economic instability (as reflected here by the deviation of actual from expected exports as a share of GDP) is expected to have a negative influence on investment decisions.[11] Similar considerations enter the specification of non-agricultural investment.

Non-agricultural investment is modelled in equation (11) as a function of agricultural value added, lagged non-agricultural output, economic instability, and capital imports. Agriculture is thus modelled as a source of inter-sectoral investment capital. As expected, agricultural value added contributes positively to non-agricultural investment and economic instability is a disincentive to investment.

Equations (12) and (13) predict prices. Equation (12) predicts the real exchange rate as a function of the foreign terms of trade (the price of exports relative to imports), the government deficit, and the nominal exchange rate.[12] The government deficit captures two effects on the real exchange rate. Fiscal deficits result in part from

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[11] Dawe (1993), as discussed further in Chapter 4, demonstrates the importance of this proxy in shaping both investment patterns and economic growth.

[12] The real exchange rate used here is calculated as $NER * P^{US}_{GDP} / P^{KEN}_{GDP}$, where NER is the nominal exchange rate, and the price series are the GDP deflators for the US and Kenya While a trade weighted deflator and exchange rate might be preferable in the numerator, this more convenient alternative performs acceptably.

government spending. Since GOK spending is strongly biased in favor of non-tradables, it tends to be inflationary and thus causes the real exchange rate to appreciate. If the government then finances the higher deficit through higher inflation, the real exchange rate further appreciates. For both reasons, the fiscal deficit enters negatively in determining the real exchange rate. The nominal exchange rate is a component of the real exchange rate. It is included here as an exogenous variable through which the GOK might try to manage the real exchange rate (which is not directly under its control). The foreign terms of trade is a component of the real exchange rate. While the expectation regarding its sign is not clear *a priori*, it makes sense that a country with a negative trade balance could experience a real depreciation when the terms of trade fall.[13]

Finally, equation (13) estimates the rural-urban terms of trade. These relative domestic prices are estimated as a function of the lagged real exchange rate agricultural output, the coffee boom, and agricultural output. Lagged real exchange rates influence the rural-urban terms of trade to the extent that agriculture tends to be more tradable than non-agriculture. Thus a real exchange rate depreciation (i.e., an increase in the price of tradables relative to the price of non-tradables) would shift relative prices in favor of agriculture. Increased agricultural output, in contrast, tends to

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[13] The logic behind this is that the real exchange rate is the price of tradables relative to the price of non-tradables The numerator is thus a weighted average of the price of importables and exportables. A fall in the foreign terms of trade implies that the price of a country's imports rises relative to the price of its exports A country with a negative trade balance would have a greater weight on imports in that weighted average. Thus, an equal percentage increase in import prices and decrease n export prices would increase the relative price of tradables, resulting in a real exchange rate depreciation Alternatively, the government may force faster nominal devaluations to compensate for declining terms of trade.

lower agricultural prices and reduce the rural-urban terms of trade. This is true of indirect taxes as well, since agricultural products dominate exports (the domestic prices of which are reduced by export taxes).

Model Solution and Validation

Once the individual equations of the model have been specified and estimated the model's performance in simulating true historical time paths for the endogenous variables depends on how well the individual equations work together as a system. The system is dynamic in that the values predicted for the endogenous variables in a given year depend on previous predictions for endogenous variables. For instance, agricultural GDP in 1980 cannot be predicted without first predicting (among other things) private agricultural investment in 1977, which in turn cannot be predicted without first predicting agricultural output in 1977, and industrial output in 1976. These variables are themselves predicted by various exogenous variables and lagged endogenous variables in other equations. This illustrates the type of relationships across equations that are traced out in solving the model. The model's dynamic structure becomes quite complicated as given changes have immediate effects which lead to second and third-round effects in the system.

An increase in agricultural GDP has several immediate effects within the model. In addition to directly increasing total GDP, it increases the trade balance, lowers the rural-urban terms of trade, and increases next period's non-agricultural output. These effects spark a set of second-round effects. Increased output increases investment in

both sectors next year (an effect reinforced by the role of the higher trade balance in agricultural investment), the lower rural-urban terms of trade reduces agricultural output next year (and increases non-agricultural output), and indirectly increases next year's total GDP through its effect on non-agricultural output. These effects, in turn, have third round effects resulting from increased investment and changes in relative prices and output, and so on.

While the impacts of these effects die out over time, the dynamic structure of the model is such that the second-round effects from changes in a given year themselves become first-round effects for other variables in the following year. Even in this relatively simple model, the full chain of events can only be viewed by actual simulation.

Simulation involves simultaneously solving all thirteen equations, given starting values for the endogenous variables and actual time paths for the exogenous variables. The simulation is dynamic in that endogenously predicted values are always used where lagged endogenous variables are explanatory variables in other equations. Thus the predicted outcomes for a given year depend on the predicted outcomes for previous years. The result is a set of predicted time paths for the endogenous variables. One can then validate the model based on how good a job it does at recreating the actual paths followed by the endogenous variables. Once one is convinced that the model faithfully recreates actual events, it is possible to perform counterfactual experiments.

The results of a "base run" of the model are presented in Appendix 3-3. The base run attempts only to recreate past events. The graphs in Appendix 3-3 compare the actual time paths for each endogenous variable against the paths predicted in the

base run. The major issue in evaluating the base run is whether the predicted time paths for the endogenous variables capture the turning points in the actual time paths. The levels are somewhat more difficult to evaluate since the model is estimated in first differences (i.e. $\Delta X = X_t - X_{t-1}$). As such, one poorly predicted first difference results in a permanent divergence *in levels* between the predicted and actual paths.

The visual assessment in Appendix 3-3 is accompanied by several tables of statistical measures of the accuracy of the model's predictions. In general, the model appears to do a good job of predicting the past. The greatest difficulties (as measured by the root mean square percentage errors) come in the predictions for agricultural investment and the price variables (the real exchange rate and the rural-urban terms of trade). Yet, even in these cases the Theil inequality coefficient is acceptably close to zero.[14]

Simulation Results

This section describes the results of several simulations undertaken with the model. The most significant results arise from using the model to calculate growth multipliers for agriculture and non-agriculture. *Simulations indicate that the growth multiplier from agriculture is nearly three times the magnitude of the multiplier from non-agriculture.* This result comes from having "shocked" the system with a one-time increase of 100 million Kenyan pounds in 1982.

[14] These statistics are explained in Appendix 3-3.

Figure 3-2 traces the *increase* in total GDP resulting from a 100 million pound shock to agricultural GDP in 1982. The immediate effect is to increase total GDP by 127.3 million pounds, reflecting the 100 million directly from agriculture and the 27.3 million from non-agriculture. The increase in non-agriculture is driven by the inter-sectoral linkages flowing from agriculture to non-agriculture. The dynamic structure of the model is such that the after effects of the shock to agricultural value added die out after four years.

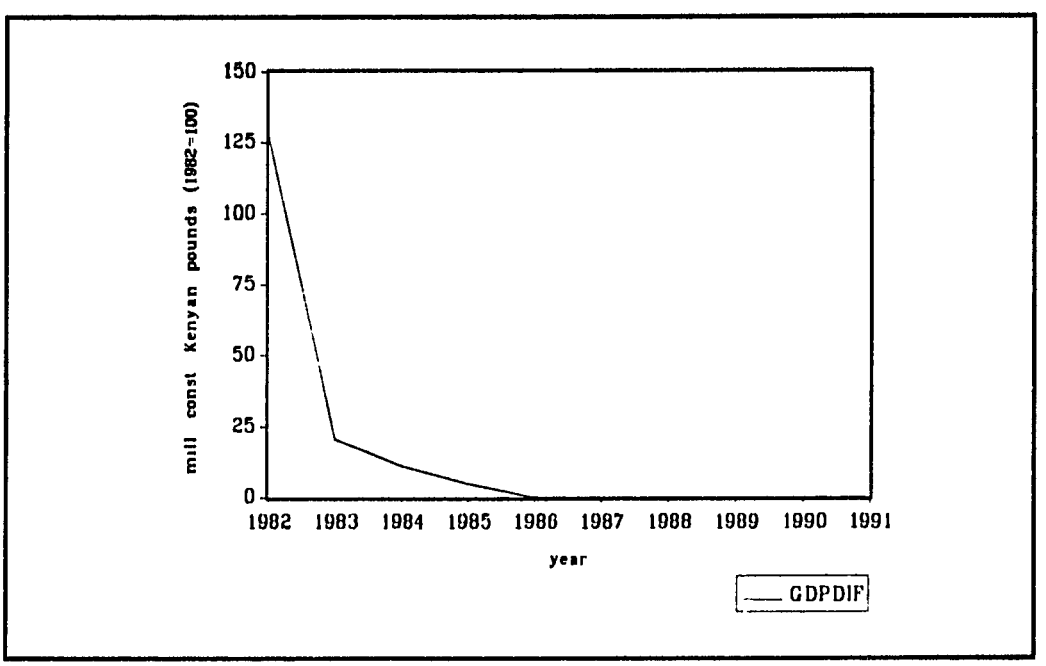

Figure 3-2 Increase to GDP from Shock to Agricultural Value Added

The agricultural growth multiplier implied by this simulation is 1.64. A 100 million pound increase in agricultural value added increases non-agricultural value added by just over 56 million over a period of four years, and (by stimulating increased capital

formation within agriculture itself) increases agricultural value added in subsequent years by approximately 8 million pounds. The addition to total GDP resulting from the 100 million pound shock to agricultural value added is thus 164 million.[15] Agriculture's contribution to non-agricultural GDP accounts for 88% of the multiplier, leaving 12% as the result of increased investment within agriculture and feedbacks to agriculture from increased output in non-agriculture.

In contrast, Figure 3-3 illustrates the increase in total GDP resulting from a 100 million pound shock to non-agricultural value added. The results show that non-agricultural growth contributes to increased agricultural growth, though the feedback in this direction is weaker.

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[15] This long-run multiplier is calculated as the sum of the *increases* in total GDP over the entire period during which increases occurred divided by the size of the initial shock Note that in a linear model, the multiplier is insensitive to both the size and the timing of the shock. For instance, had the shock been 10 million rather than 100 million, the long-run increase in GDP would have been 16 4 million, which divided by 10 yields the same multiplier.

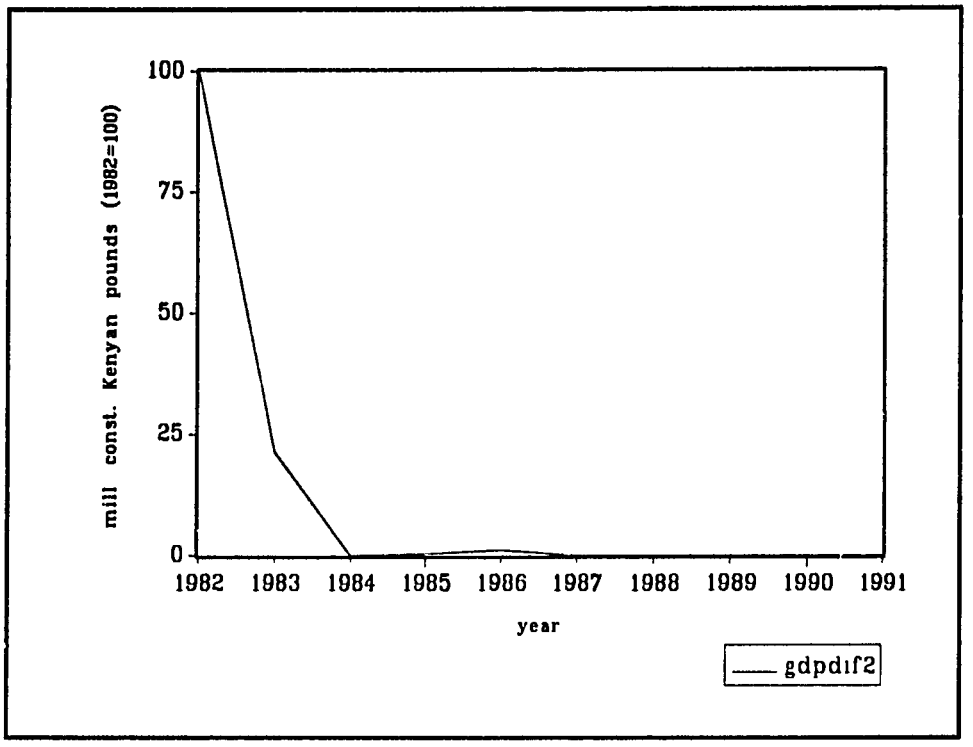

Figure 3-3 Increase In GDP from Shock to Non-Agriculture

The long-run non-agricultural growth multiplier is 1.23. In this case, total GDP increases in the first year after the shock (since it is lagged non-agricultural value added that affects agriculture) by nearly 21.5 million pounds. Of this, 16.9 comes from inter-sectoral linkages that boost agricultural value added, while re-investment within non-agriculture increases non-agricultural value added by 4.6 million in the year after the shock. The addition to agricultural value added feeds back in subsequent periods to increase non-agricultural value added still further. The effects die out after the fourth post-shock year, the increase to total GDP having summed to 23 million. Nearly eighty percent of this increase results from non-agriculture's contribution to agricultural output,

while just under 20% results from increased investment within non-agriculture and feedbacks to non-agriculture from the boost to agriculture.

It is clear that a given increase in agricultural income has a substantially greater impact on national income than an equivalent increase in non-agricultural income. Table 3-2 summarizes the long-run effects of equivalent shocks to agricultural and non-agricultural value added.

Table 3-2 Sectoral Disaggregation of Long-Run Growth Multipliers

	Long-Run Increase (net of initial shock) in		
100 mill K £ shock to	Agricultural GDP	Non-Agricultural GDP	Total GDP
Agriculture	8 (12%)	56 (88%)	64 (100%)
Non-Agriculture	18 (78%)	5 (22%)	23 (100%)

An alternative simulation is to ask what would have happened to non-agricultural and total GDP growth rates if the agricultural growth rate had been 1 percent greater each year than it actually was. Table 3-3 summarizes the results of this experiment.

Table 3-3 Changes in the Annual Growth Rates of Non-Agriculture and GDP with Sustained Agricultural Growth Increases of 1% per year (1981-91)

	base run	post-shock
Non-Ag GDP Growth Rate	4.53%	4.74%
Total GDP Growth Rate	3.97%	4.40%

Table 3-3 shows that in response to a sustained 1% per year increase in the growth of agricultural GDP, the growth rate of non-agricultural GDP increases by just over 0.2 percentage points, from 4.53% to 4.74% per year during the simulation period. The growth rate of total GDP increases by 0.43 percentage points when agricultural GDP grows 1% faster. Given that agriculture accounted directly for 29% of GDP during this period, agriculture's direct contribution to total GDP growth resulting from a 1% increase in the agricultural growth rate would be 0.29 percentage points. The additional 0.14 percentage point increase in the growth rate of total GDP is the result feedbacks from agriculture to non-agriculture.

Table 3-4 shows the results of a sustained 1% increase in the growth rate of non-agriculture on the annual growth rates of agriculture and total GDP.

Table 3-4 Changes in the Annual Growth Rates of Agriculture and GDP with Non-Agricultural Growth Increases of 1% per year (1981-91)

	base run	post-shock
Agricultural GDP	2.66%	3 11%
Total GDP	3.97%	4.83%

The central comparison between tables 3-3 and 3-4 is in the relative increases in total GDP resulting from hypothetical sustained 1% per year increases in the growth rates of agriculture and non-agriculture. Table 3-4 shows that a 1% increase in the growth rate of non-agriculture raises the GDP growth rate by 0.85 percentage points, as opposed to the 0.43 percentage point increase in GDP growth that results from a 1% increase in agricultural GDP. Yet, non-agriculture comprises 71% of the economy on

average over the simulation period. Thus, with *no* inter-sectoral linkages, a 1% increase in non-agricultural growth would increase total GDP growth by 0.71 percentage points. The indirect effect from non-agricultural growth linkages is only 0.14 percentage points. Thus, non-agriculture's indirect contribution to more rapid economic growth is only 20% of its total contribution, whereas agriculture's indirect contribution is 33% of its total contribution. This contrast reflects the higher growth multiplier generated by agricultural income.

Although this model is not sufficiently detailed to perform complicated policy simulations, several additional simulations are possible. Data provided by the Kenyan Ministry of Planning and National Development make it possible to distinguish between public and private investment in agriculture and non-agriculture.[16] The disparity between the public investment growth multipliers for agriculture and non-agriculture are striking: the growth multiplier for public investments in agriculture is 1.96, while the multiplier for investments in non-agriculture is 0.37. This disparity could reflect the combined results of two separate effects. As shown above, the growth multiplier for *any* additional sector income is greater for agriculture than for non-agriculture. In addition, it may well be the case that marginal rates of return to investments have been

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[16] Wilson (1993) divides capital stock and capital formation into the following categories. residential buildings, non-residential buildings, construction and works, land improvement and plantation development, transport equipment, machinery and other equipment, and breeding stock and dairy cattle The distinction between public and private capital stocks lies in the levels and mix of stocks across these categories. In both cases, machinery and other equipment is the largest category of investment Non-residential buildings tends to be a relatively larger share of public sector capital stock in agriculture, while construction and works tends to account for a relatively larger share of private sector agricultural capital Land improvement also tends to be a relatively larger of share of private sector agricultural investment In addition, the public sector holds no breeding stock and dairy cattle

greater in agriculture than in non-agriculture. As described in Chapter 2, cross-sector differences in the marginal productivity of capital (e.g., capital market disequilibria) are symptomatic of "urban bias."

History has demonstrated repeatedly that Kenyan agriculture is prone to drought. Given agriculture's weight in the economy, as well as the strong agricultural growth linkages demonstrated above, droughts necessarily have macroeconomic implications. Using the present model to simulate a one year drought in 1985 suggests that these impacts are substantial. The macroeconomy takes four years to fully recover from a one-year drought. During the simulated drought year of 1985, GDP (at factor prices) falls by 112 million pounds -- equivalent to 3% of GDP that year. Over the course of four years, the simulated drought costs just over 143 million pounds in lost GDP. Of this total loss, only 62% is from agriculture itself. As Delgado, et. al. point out, growth linkages work in reverse: 38% of the total value added losses from drought occur in non-agriculture.[17]

One can also perform a crude simulation of agricultural price policy's effect on economic growth (though, as noted above, the model's lack of detail makes this simulation illustrative). Figure 3-4 illustrates the effects of a one-time 10% increase in the rural-urban terms of trade (imposed in 1984).[18]

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[17] Delgado, et.al. (1994)

[18] Figure 3-4 plots the first difference of the difference between the pre- and post-shock values for each series.

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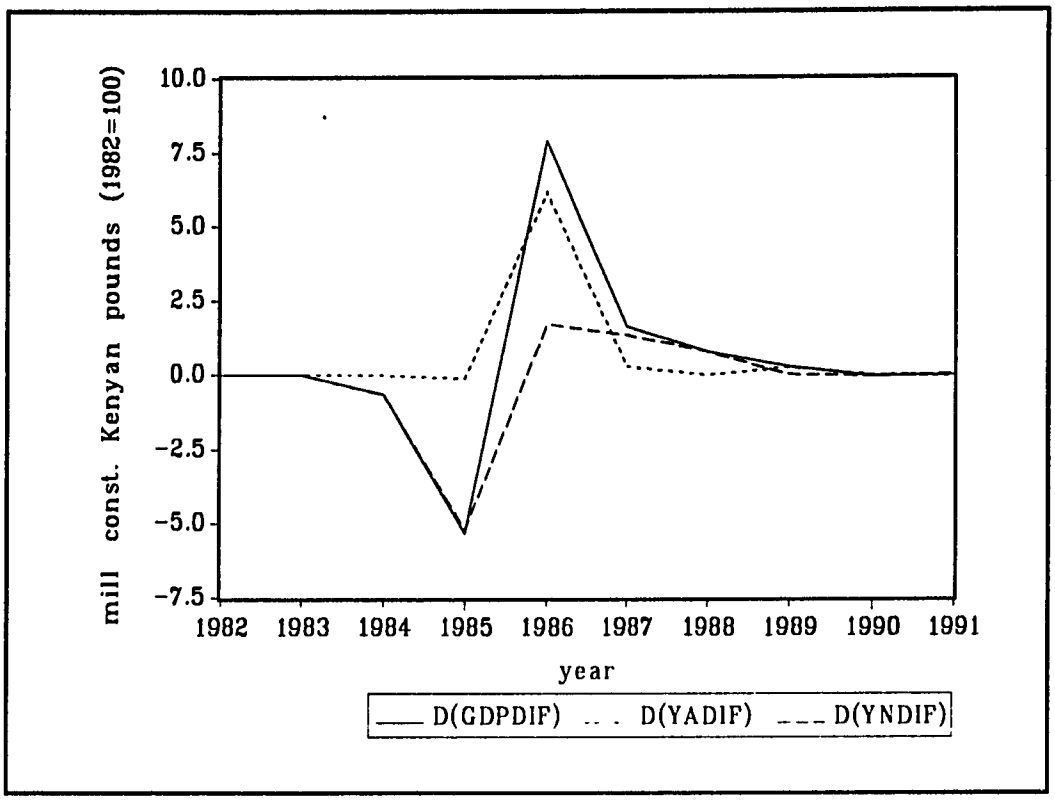

Figure 3-4 ***Differences in Total and Sectoral GDP Resulting from Rural-Urban Terms of Trade Shock***

The net long-run effect of increasing the rural-urban terms of trade by 10% in 1984 is to increase total GDP by 4.67 million (1982) pounds. Figure 3-4 shows that the immediate effect is a slight reduction in non-agricultural value added, followed by a greater reduction the following year. This results from the contemporaneous effect of the rural-urban terms of trade on value added in the basic and capital goods sub-sector and the lagged negative effect of the rural-urban terms of trade on value added in the consumer goods sub-sector.[19] With a two-year lag, however, the terms of trade shock

[19] See Table 3-1 for the lag specification in the underlying equations.

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has a substantial positive effect on agricultural value added, increasing it by 6.18 million (1982) pounds in 1986. This effect, alone, more than compensates for the reduction in non-agricultural value added. Yet, the increase in agricultural value added also feeds back into an increase in non-agricultural value added, adding to the net benefits of the initial shock. This experiment suggests that providing greater price incentives to agriculture can stimulate the entire Kenyan economy. Note, however, that the magnitude of these effects is small relative to the size of the economy: the increase in agricultural value added is just over 0.6 percent of total agricultural value added in 1986.

This chapter has presented a two-sector simulation model of the Kenyan economy with which it is possible to estimate agricultural and non-agricultural growth multipliers on the national level. The central result of this exercise is to demonstrate that the agricultural growth multiplier is substantially greater than the non-agricultural growth multiplier. An additional hundred shillings of agricultural value added increases total GDP by 164 shillings, while the increase in non-agricultural value added increases total GDP by only 123 shillings. Net of the initial shocks, the magnitude of non-agriculture's multiplier is just over one-third that of agriculture.

Consistency with Other Studies

The results are entirely consistent with previous regional-level analyses of agricultural growth multipliers and complements those earlier results. Delgado, et.al., have recently demonstrated much stronger agricultural growth linkages for several

African countries than had previously been thought to exist.[20] Given the nature of their regional models, the magnitude of the agricultural growth multipliers is quite sensitive to the categorization of goods as being either tradable or non-tradable. The earlier growth linkages literature, taking Asia as its example, counted food as tradable. As such, additional spending on food does not contribute to the agricultural growth multiplier, the consumption component of which relies on increased spending on non-tradables. Work in this vein found agricultural growth multipliers in several Asian regional cases on the order of 1.6 for India and 1.8 for the Muda River region of Malaysia.[21] Applying the "Asian" assumptions to the application of these models in Africa, agricultural growth multipliers tended to be lower than those found in Asia. Multipliers on the order of 1.5 were found for regions of Sierra Leone and Nigeria, leading those authors to conclude that consumption linkages were weaker in Africa than in Asia.

Arguing that the assumption that all foodgrains are tradable is inappropriate for Sub-Saharan Africa, Delgado, et.al., use the same methodology to estimate agricultural growth multipliers for regions in Burkina Faso, Zambia, Senegal and Niger. Their re-categorization of food as non-tradable results in substantially higher agricultural growth multipliers in their study zones than had previously been thought to exist. They find agricultural growth multipliers of 2.75 in Burkina Faso, 2.48 in Zambia, 1.97 in Senegal, and 1.96 in Niger.

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[20] *Ibid.*

[21] These results are based on a series of articles and books, including: Bell, Hazell and Slade (1982), Hazell and Röell (1983), Hazell and Haggblade (1990), Hazell (1984), Hazell, Ramasamy, and Rajagopalan (1991), Haggblade, Hazell, and Brown (1987), and Dorosh and Haggblade (1993).

Applying a variant of this approach to the Kutu region of Kenya's Central Province, Lewis and Thorbecke have found agricultural growth multipliers of approximately 1.45, as compared with non-agricultural growth multipliers on the order of 0.8.[22] That their multipliers are lower than those found for Kenya in this chapter is primarily the result of differences in our methodologies. Using the model on which the present Kenyan model was based, Rangarajan calculated India's agricultural growth multiplier during the 1960's to be 1.7 as compared with a multiplier of 1.5 for industry.[23] As in the present case, Rangarajan's analysis was carried out with national aggregate data.

This extremely valuable literature has firmly established the superior linkages derived from agriculture, and has taken advantage of its detailed data sources to measure the effects of specific forward and backward linkages from agriculture to non-agriculture. The regional studies, however, rely on a particular methodology that prevents their results from being generalized directly to the level of national income. The model presented in this chapter builds on those more detailed findings. While we do not explicitly model those micro-linkages, the present model captures their effects on the national level.

The conceptual model presented in Chapter 2 suggests that there may be more subtle inter-sectoral linkages flowing from agriculture that have not been measured in the previous literature. The model presented in this chapter cannot distinguish among

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[22] Lewis and Thorbecke (1992)

[23] Rangarajan (1982)

these particular linkages. The analysis in the following chapter provides a step in this direction by assessing the effects of agricultural productivity on non-agricultural productivity.

Appendix 3-1

Variable Names

All variables are measures in millions of constant Kenyan pounds (1982=100)

YA = value added in agriculture
GI = gross capital formation
GIA = gross capital formation in agriculture
GIN = gross capital formation in non-agriculture
YBK = value added in basic and capital goods
YC = value added in consumer goods
YN = value added in non-agriculture
KIMP = capital goods imports
YMKTP = GDP at market prices
YFACP = GDP at factor prices
RUTT = rural-urban terms of trade
GOVEXP = government expenditures
TOT = foreign terms of trade =
RER = real exchange rate = $NER * P_{GDP}^{US} / P_{GDP}^{KEN}$
INSTAB = a proxy for macroeconomic (export) instability
DROUGHT = dummy variable = 1 for drought years
DELSTK = change in capital stocks
TDBAL = exports - imports
INDTXSUB = indirect taxes and subsidies
NER = nominal exchange rate (Ksh/US$)
GOVDEF = GOK fiscal deficit
CFBOOM = dummy for coffee boom
GINP = gross capital formation in non-agriculture originating in the public sector
GIAP = gross capital formation in agriculture originating in the public sector
CONP = private consumption
GOV = government consumption

Appendix 3-2

Parameter Estimates and Regressions

d(GI)=1.*d(DELSTK)+1.*d(GIA)+1.*d(GIN)+1.*d(GIAP)+1.*d(GINP)

d(YFACP)=1.*d(YA)+1.*d(YN)

d(YN)=1.*d(YC)+1.*d(YBK)

d(YMKTP)=1.*d(INDTXSUB)+1.*d(YFACP)

d(CONP)=1.*d(YMKTP)-1.*d(GI)-1.*d(GOV)-1.*d(TDBAL)

D(RUTT)=-2.735187D-02+2.526159D-02*D(RER(-1))+.486953*CFBOOM-6.015151D-04*D(YA)+5.81938D-02*DUM7981+7 119644D-02*DUM86+[AR(1)=.8463119,AR(2)=-.1354623]

D(YBK)=9.109008+1.63352D-02*D(GIN(-1))+.1434708*D(YA(-2))-6.417593*D(RUTT)+.1005783*D(GINP(-1))-9.799778*DROWT-34.80751*DUM83+7.575962*D(TOT)+[AR(1)=.6890892]

D(RER)=4.850584D-02- 7633847*D(TOT)+.4144192*D(NER)-1.978638D-03*D(GOVEXP)+.7539111*DUM81+[AR(1)=.5142609]

D(GIA)=-5.653919+.2085535*D(YA)-1025.418*D(XDEV5MA)+4.436574D-02*D(IMPKI)-.5224843*D(YBK(-1))+2.460446*D(NER)+13.40627*DUM81

D(TDBAL)=6.669277+.9388886*D(YA)+.4482454*D(YN)-420.7854*TDBDUM-2.710021*D(INDTXSUB)-229.8336*D(TOT)+195.1855*DUM79+[AR(1)=-.6088726]

D(YC)=88.66331+ 2343744*D(GIN(-1))+.2694763*D(YA)-51.29518*D(RUTT(-1))+.2413846*D(INDTXSUB)+.2008516*D(GINP(-1))-36.46856*DUM82+[AR(1)=.7232058]

D(YA)=27.44015+69.67991*D(RUTT(-2))+.1181222*D(GIA(-3))+.1686954*D(YN(-1))-80.24222*DROWT+1.18017*D(GIAP(-3))+59.87761*DUM80-11.64939*DUM88+[AR(1)=-.646119]

D(GIN)=15.21712+.2059498*D(IMPKI)-2262.041*D(INSTAB)+.4622626*D(YA)+26.18062*DUM7981-.2971255*D(YN(-1))+[AR(1)=-1.122806,AR(2)=-.7109035]

Regression Output for Estimated Equations

LS // Dependent Variable is D(YC)
SMPL range: 1975 - 1992
Number of observations: 18

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	88.663316	10.290345	8.6161653	0.0000
D(GIN(-1))	0.2343744	0.0495962	4.7256505	0.0008
D(YA)	0.2694763	0.0799425	3.3708759	0.0071
D(RUTT(-1))	-51.295184	28.728216	-1.7855332	0.1045
D(INDTXSUB)	0.2413846	0.0557241	4.3317835	0.0015
D(GINP(-1))	0.2008517	0.0656165	3.0609955	0.0120
DUM82	-36.468561	10.311969	-3.5365275	0.0054
AR(1)	0.7232058	0.1891569	3.8233123	0.0034

R-squared	0.909287	Mean of dependent var	94.50267
Adjusted R-squared	0.845787	S.D. of dependent var	28.59057
S.E. of regression	11.22750	Sum of squared resid	1260.567
Log likelihood	-63.78140	F-statistic	14.31961
Durbin-Watson stat	1.907529	Prob(F-statistic)	0.000178

LS // Dependent Variable is D(YBK)
Date: 6-02-1994 / Time: 22:35
SMPL range: 1976 - 1992
Number of observations: 17

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	9.1090081	3.8165454	2.3867155	0.0441
D(YA(-2))	0.1434709	0.0391711	3.6626737	0.0064
D(GIN(-1))	0.0163352	0.0237228	0.6885875	0.5106
D(RUTT)	-6.4175931	21.085848	-0.3043555	0.7686
D(GINP(-1))	0.1005783	0.0344205	2.9220490	0.0192
DROWT	-9.7997782	3.2134318	-3.0496301	0.0158
D(TOT)	7.5759626	10.692803	0.7085105	0.4987
DUM83	-34.807517	7.6460854	-4.5523317	0.0019
AR(1)	0.6890893	0.2595002	2.6554483	0.0290

R-squared	0.926395	Mean of dependent var	8.771764
Adjusted R-squared	0.852790	S.D. of dependent var	11.81798
S.E. of regression	4.534317	Sum of squared resid	154.4803
Log likelihood	-43.41336	F-statistic	12.58604
Durbin-Watson stat	1.403188	Prob(F-statistic)	0.000857

LS // Dependent Variable is D(YA)
Date: 6-02-1994 / Time: 22:40
SMPL range: 1977 - 1992
Number of observations: 16
Convergence achieved after 8 iterations

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	27.440153	7.0350346	3.9005000	0.0059
D(RUTT(-2))	69.679916	26.365042	2.6428904	0.0333
D(GIA(-3))	0.1181222	0.3058709	0.3861833	0.7108
D(YN(-1))	0.1686954	0.0632801	2.6658513	0.0322
DROWT	-80.242223	5.7764305	-13.891316	0.0000
D(GIAP(-3))	1.1801705	0.6873965	1.7168702	0.1297
DUM80	59.877614	16.461383	3.6374596	0.0083
DUM88	-11.649398	12.607577	-0.9239998	0.3862
AR(1)	-0.6461191	0.3010104	-2.1465007	0.0690

R-squared	0.956525	Mean of dependent var	24.63977
Adjusted R-squared	0.906840	S.D. of dependent var	36.65674
S.E. of regression	11.18843	Sum of squared resid	876.2666
Log likelihood	-54.72767	F-statistic	19.25161
Durbin-Watson stat	1.724313	Prob(F-statistic)	0.000414

LS // Dependent Variable is D(TDBAL)
Date: 6-02-1994 / Time: 22:42
SMPL range: 1974 - 1992
Number of observations: 19

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	6.6692770	32.503141	0.2051887	0.8412
D(YA)	0.9388886	0.4271799	2.1978761	0.0503
D(YN)	0.4482455	0.3749269	1.1955543	0.2570
TDBDUM	-420.78544	66.834497	-6.2959319	0.0001
D(INDTXSUB)	-2.7100213	0.3295688	-8.2229305	0.0000
D(TOT)	-229.83363	82.347408	-2.7910244	0.0176
DUM79	195.18553	71.101776	2.7451569	0.0191
AR(1)	-0.6088726	0.2218099	-2.7450197	0.0191

R-squared	0.930150	Mean of dependent var	16.02737
Adjusted R-squared	0.885701	S.D. of dependent var	184.5828
S.E. of regression	62.40407	Sum of squared resid	42836.95
Log likelihood	-100.3066	F-statistic	20.92591
Durbin-Watson stat	2.374019	Prob(F-statistic)	0.000016

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LS // Dependent Variable is D(GIN)
Date: 6-02-1994 / Time: 22:46
SMPL range: 1976 - 1991
Number of observations: 16
Convergence achieved after 5 iterations

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	15.217121	7.2172648	2.1084333	0.0680
D(YA)	0.4622626	0.1249345	3.7000407	0.0060
D(YN(-1))	-0.2971256	0.0652916	-4.5507446	0.0019
D(XDEV5MA)	-2262.0416	971.51436	-2.3283666	0.0483
D(IMPKI)	0.2059499	0.0374699	5.4964092	0.0006
DUM7981	26.180623	10.504400	2.4923482	0.0374
AR(1)	-1.1228061	0.1889299	-5.9429780	0.0003
AR(2)	-0.7109035	0.1514858	-4.6928735	0.0016

R-squared	0.912980	Mean of dependent var	2.320313
Adjusted R-squared	0.836837	S.D. of dependent var	49.13009
S.E. of regression	19.84531	Sum of squared resid	3150.690
Log likelihood	-64.96532	F-statistic	11.99041
Durbin-Watson stat	2.497426	Prob(F-statistic)	0.001124

LS // Dependent Variable is D(GIA)
Date: 6-02-1994 / Time: 23:07
SMPL range: 1974 - 1991
Number of observations: 18

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	-5.6539190	3.0343683	-1.8632936	0.0893
D(YA)	0.2085535	0.0664291	3.1394916	0.0094
D(IMPKI)	0.0443657	0.0119843	3.7019789	0.0035
D(YBK(-1))	-0.5224844	0.1649337	-3.1678457	0.0090
D(XDEV5MA)	-1025.4187	486.20135	-2.1090413	0.0587
D(NER)	2.4604460	1.4158711	1.7377613	0.1101
DUM81	13.406271	8.1521707	1.6445033	0.1283

R-squared	0.750350	Mean of dependent var	0.280944
Adjusted R-squared	0.614177	S.D. of dependent var	11.24547
S.E. of regression	6.985081	Sum of squared resid	536.7049
Log likelihood	-56.09658	F-statistic	5.510282
Durbin-Watson stat	1.830837	Prob(F-statistic)	0.007361

LS // Dependent Variable is D(RER)
Date: 6-02-1994 / Time: 23:07
SMPL range: 1974 - 1992
Number of observations: 19
Convergence achieved after 8 iterations

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	0.0485058	0.2330411	0.2081429	0.8383
D(NER)	0.4144192	0.0827298	5.0093127	0.0002
D(GOVEXP)	-0.0019786	0.0006094	-3.2469023	0.0064
D(TOT)	-0.7633848	0.3690654	-2.0684266	0.0591
DUM81	0.7539111	0.3238784	2.3277599	0.0367
AR(1)	0.5142609	0.2749517	1.8703678	0.0841

R-squared	0.888809	Mean of dependent var	0.503051
Adjusted R-squared	0.846044	S.D. of dependent var	0.908695
S.E. of regression	0.356547	Sum of squared resid	1.652635
Log likelihood	-3.760188	F-statistic	20.78325
Durbin-Watson stat	1.589225	Prob(F-statistic)	0.000009

LS // Dependent Variable is D(RUTT)
Date: 6-02-1994 / Time: 23:08
SMPL range: 1976 - 1992
Number of observations: 17
Convergence achieved after 7 iterations

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	-0.0273519	0.0452940	-0.6038745	0.5608
D(RER(-1))	0.0252616	0.0171777	1.4706036	0.1755
CFBOOM	0.4869531	0.0693673	7.0199273	0.0001
D(YA)	-0.0006015	0.0003061	-1.9652645	0.0810
DUM7981	0.0581938	0.0230783	2.5215849	0.0327
DUM86	0.0711964	0.0440473	1.6163637	0.1405
AR(1)	0.8463120	0.1266426	6.6826800	0.0001
AR(2)	-0.1354624	0.1245489	-1.0876238	0.3050

R-squared	0.899590	Mean of dependent var	-0.003181
Adjusted R-squared	0.821493	S.D. of dependent var	0.101332
S.E. of regression	0.042813	Sum of squared resid	0.016497
Log likelihood	34.84949	F-statistic	11.51889
Durbin-Watson stat	1.918746	Prob(F-statistic)	0.000754

Appendix 3-3

Descriptive Statistics and Graphs for the Simulation Base Run

Table A3-1 Actual versus Predicted Mean Square Errors (Variables in Levels)

VARIABLE	RMSE	RMSPE
YA	14.17	1.35
CONP	83.57	3.11
GIA	13.43	27.08
GIN	14.33	3.94
GI	23.94	2.67
YBK	33.3	11.84
YC	25.85	1.06
YN	56.1	2.15
YFACP	69.38	1.89
RER	1.03	7.37
TDBAL	42.13	78.26
RUTT	0.1	9.51

RMSE = root mean square error *RMSPE = root mean square percentage error*

$$RMSE = \sqrt{\frac{1}{T}\sum_{t=1}^{T}(Y_t^s - Y_t^a)^2}$$

$$RMSPE = \sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(\frac{Y_t^s - Y_t^a}{Y_t^a}\right)^2}$$

Table A3-2 Theil Inequality Statistics and Decomposition (Variables in Levels)

		Proportion Resulting from:		
VARIABLE	Theil Inequality	bias	variance	covariance
YA	0.007	0.65	0.11	0.19
CONP	0.016	0.62	0.1	0.25
GIA	0.113	0.53	0.01	0.43
GIN	0.019	0.08	0	0.91
GI	0.014	0.34	0.04	0.62
YBK	0.065	0.76	0.1	0.09
YC	0.006	0.39	0.31	0.28
YN	0.012	0.65	0.22	0.09
YFACP	0.01	0.66	0.19	0.1
RER	0.0444	0.52	0.3	0.14
TDBAL	0.059	0.01	0.06	0.92
RUTT	0.047	0.1	0.03	0.86

Table A3-3 Theil Inequality Statistics and Decomposition (Variables in First Differences)

VARIABLE	Theil Inequality	Proportion Resulting from: bias	variance	covariance
YA	.094	.05	.01	.94
CONP	.159	.00	.05	.94
GIA	.271	.03	.04	.92
GIN	.232	.00	.05	.95
GI	.079	.00	.00	1.0
YBK	.165	.16	.00	.83
YC	.047	.12	.01	.86
YN	.048	.24	.00	.76
YFACP	.053	.21	.01	.77
RER	.153	.11	.21	.67
TDBAL	.168	.00	.01	.99
RUTT	.221	.01	.00	.99

$$\textit{Theil Inequality} = \frac{\sqrt{\frac{1}{T}\sum_{t=1}^{T}(Y_t^s - Y_t^a)^2}}{\sqrt{\frac{1}{T}\sum_{t=1}^{T}(Y_t^s)^2} + \sqrt{\frac{1}{T}\sum_{t=1}^{T}(Y_t^a)^2}}$$

$$\textit{bias share} = \frac{(\bar{Y}^s - \bar{Y}^a)^2}{(1/T)\sum (Y_t^s - Y_t^a)^2}$$

$$\textit{variance share} = \frac{(\sigma_s - \sigma_a)^2}{(1/T)\sum (Y_t^s - Y_t^a)^2}$$

$$\textit{covariance share} = \frac{2(1-\rho)\sigma_s\sigma_a}{(1/T)\sum (Y_t^s - Y_t^a)^2}$$

where $\bar{Y}^s$, $\bar{Y}^a$, σ_s, σ_a are the means the sample standard deviations of the simulated and predicted variables, and ρ is the correlation coefficient of thesimulated and predicted variable.

A Theil inequality score of 0 indicates a perfect fit, while a score of 1 indicates the worst possible fit. Ideally, the bias and variance shares will be zero ande the covariance share will be 1.

In assessing the decomposition of the Theil inequality coefficient note that Table A3-2 provides the results based on *levels* of predicted and actual variables, while Table A3-3 is based on the *first differences.* Since the model was estimated in first differences, the decomposition is most valid in the first differences table, in which case the covariance proportion is generally high.

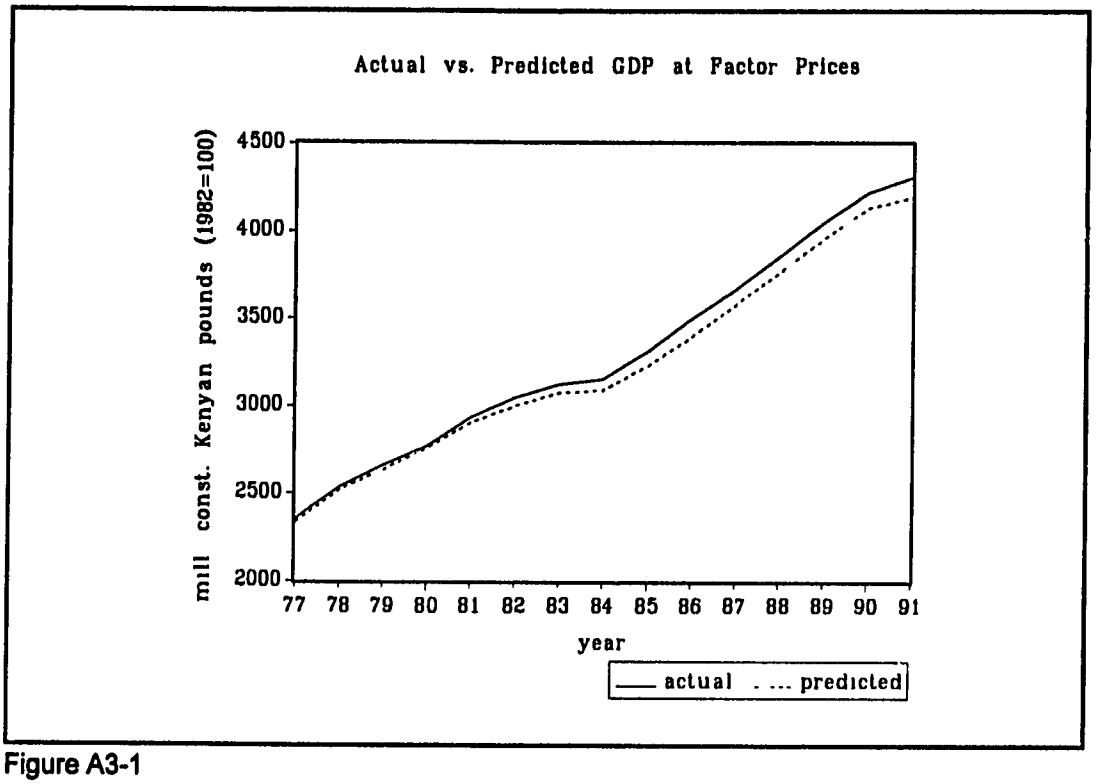

Figure A3-1

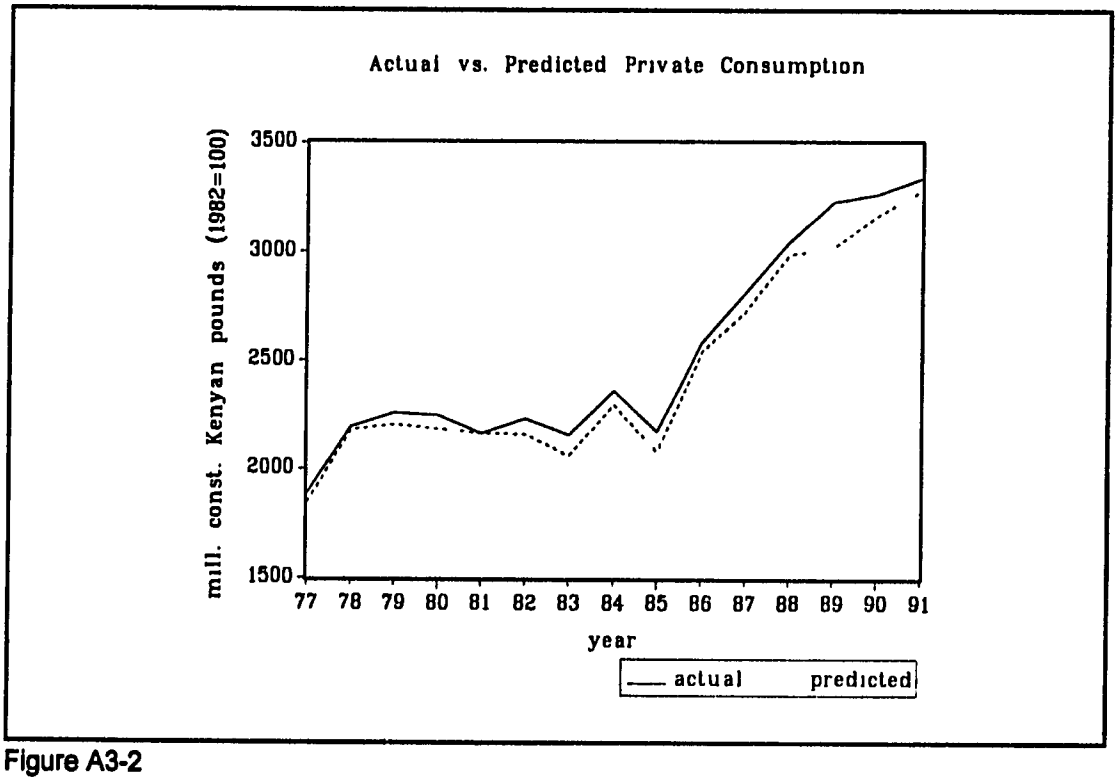

Figure A3-2

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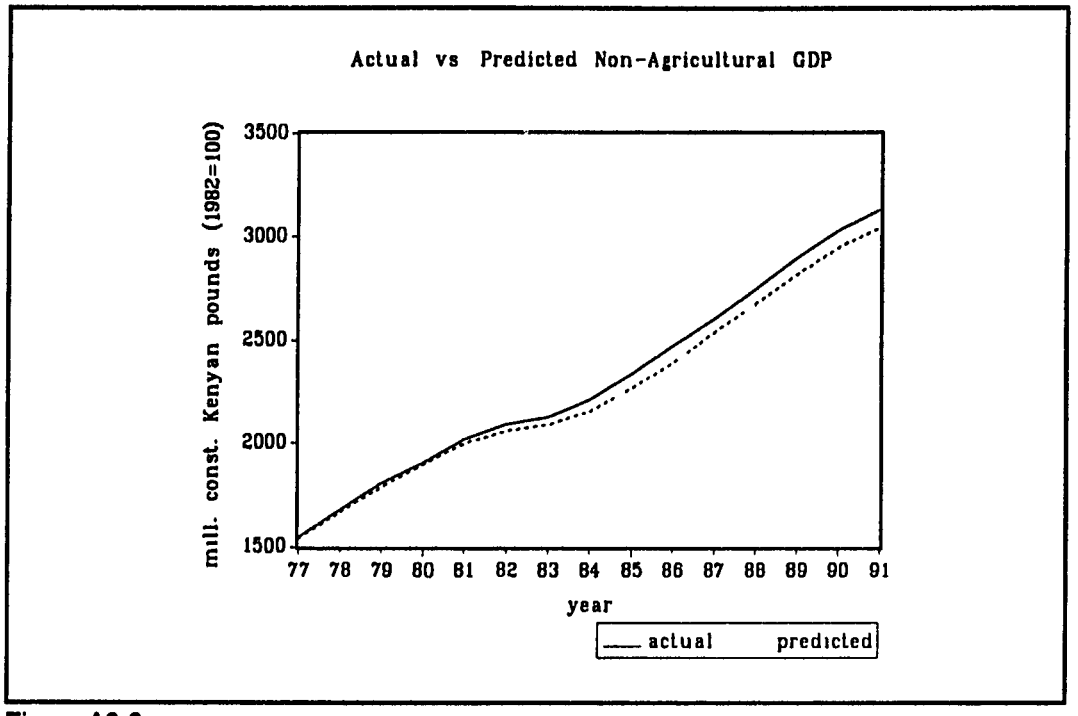

Figure A3-3

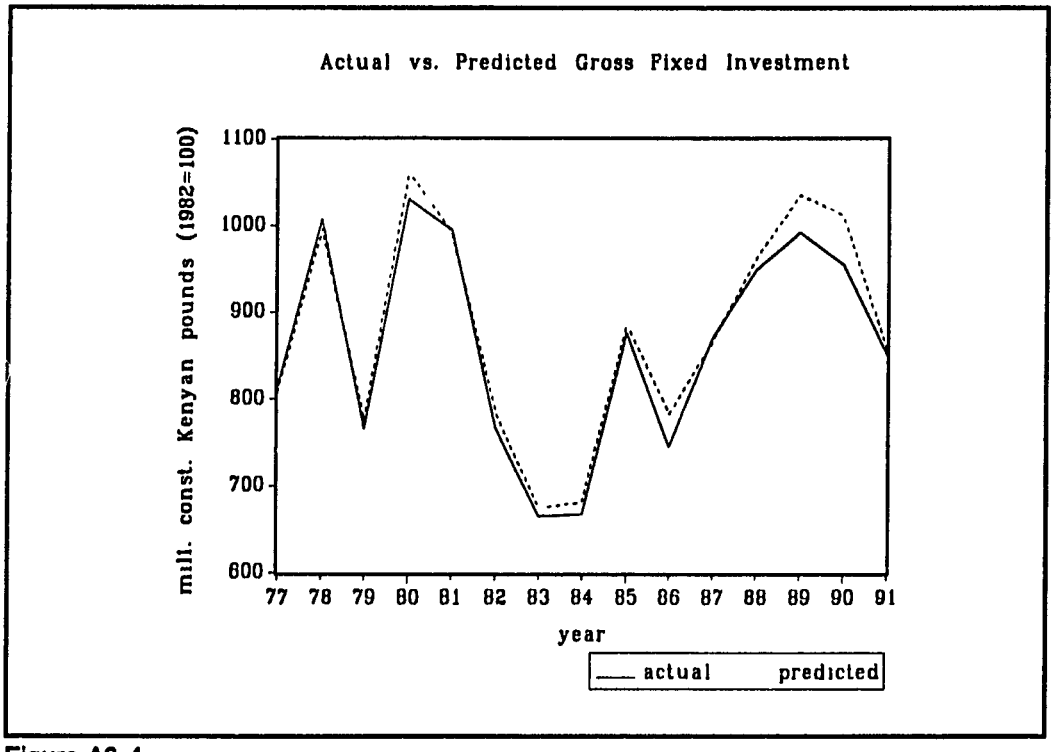

Figure A3-4

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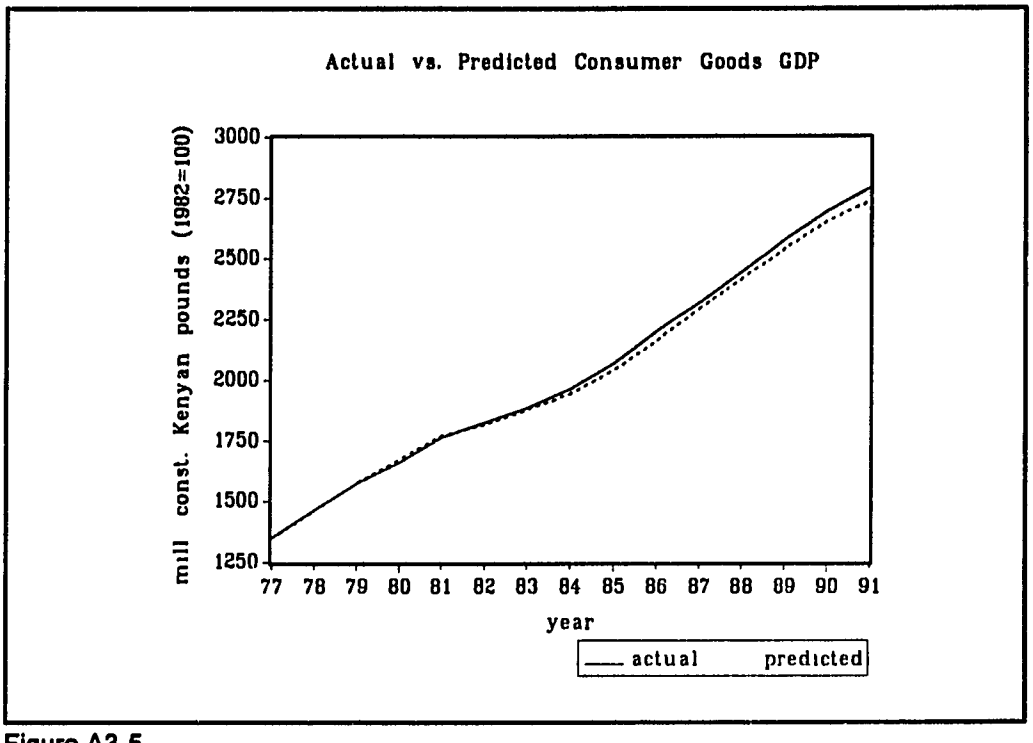

Figure A3-5

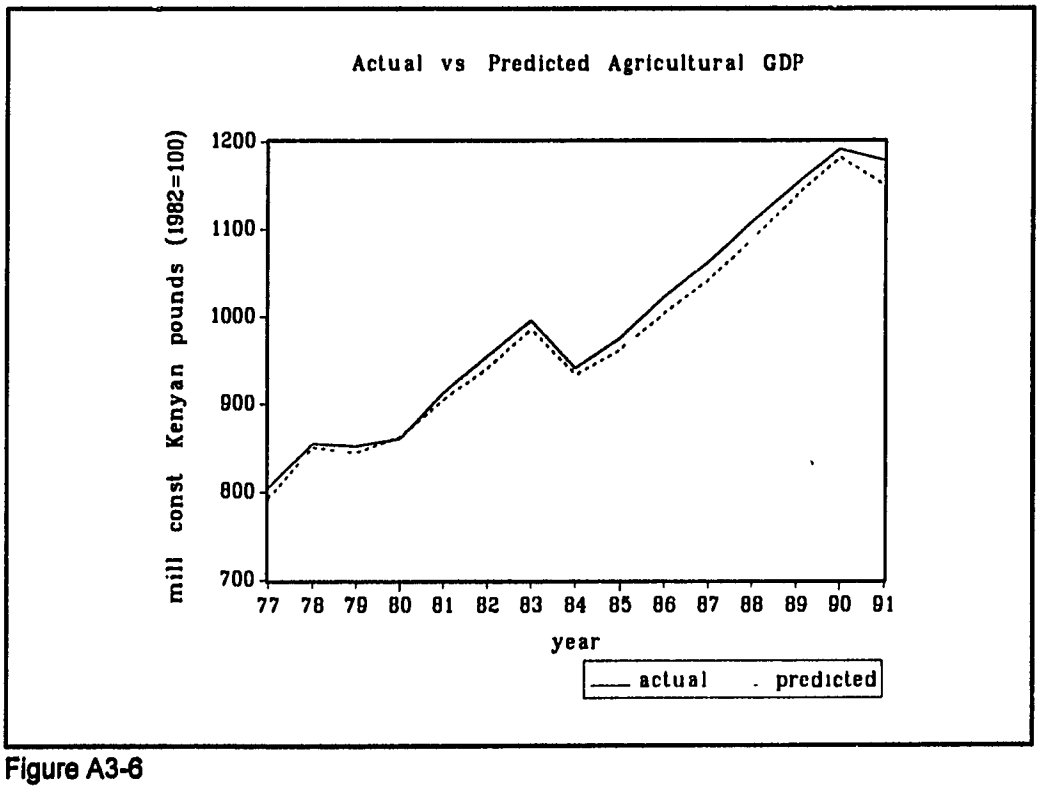

Figure A3-6

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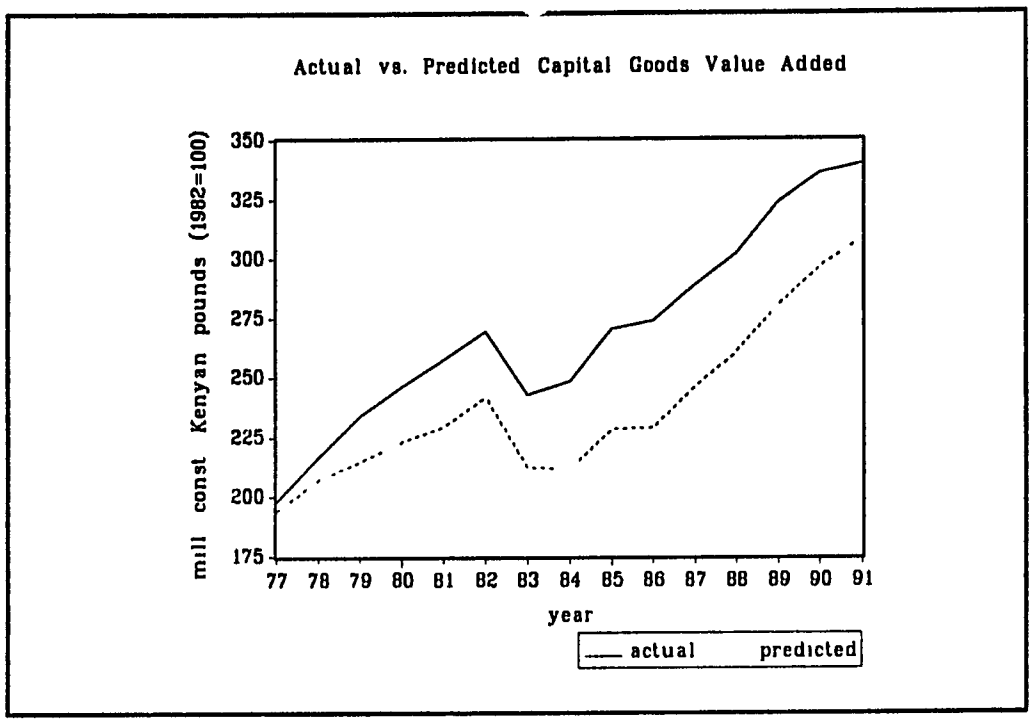

Figure A3-7a

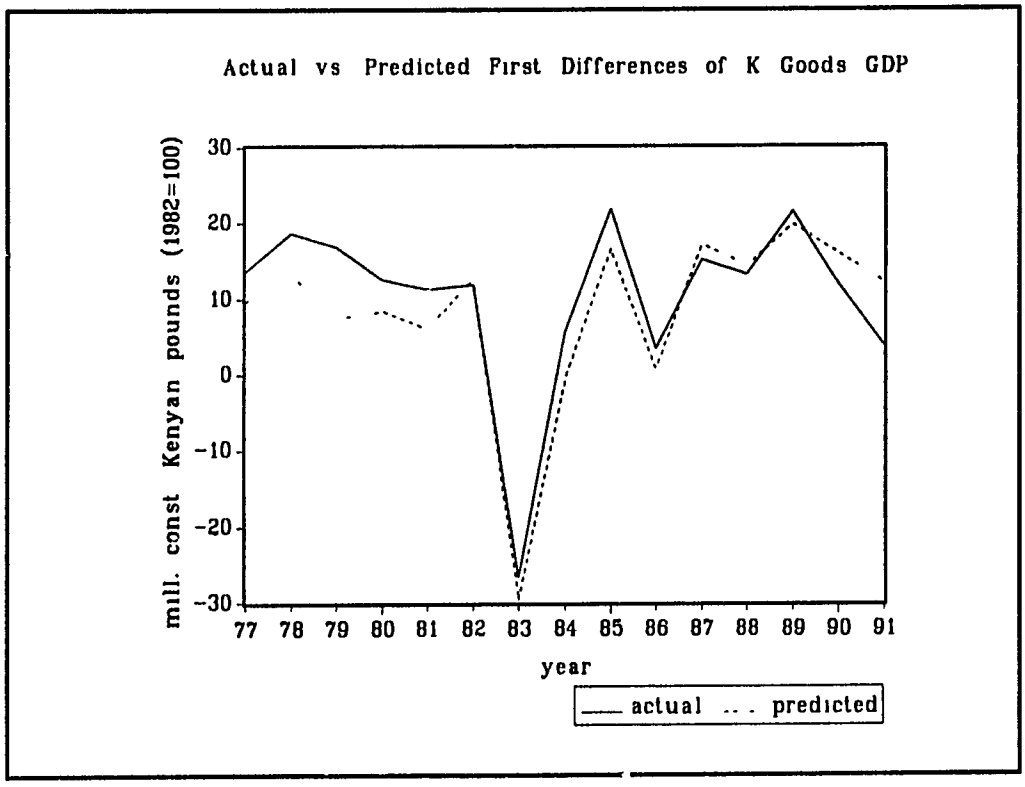

Figure A3-7b

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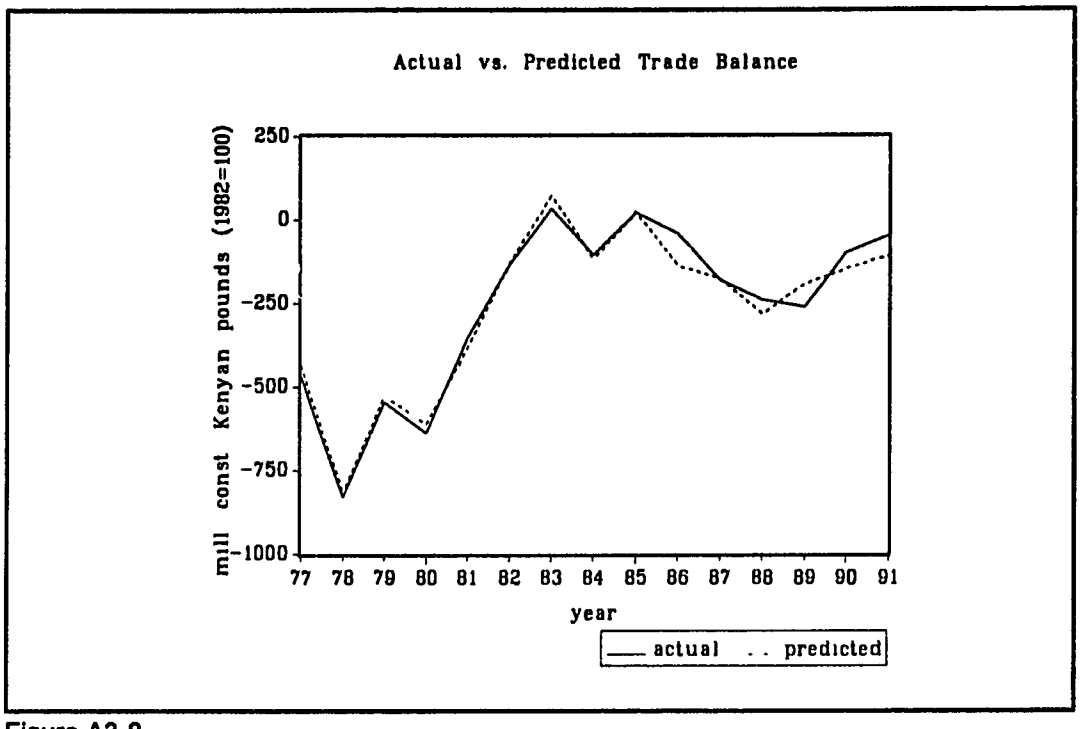

Figure A3-8

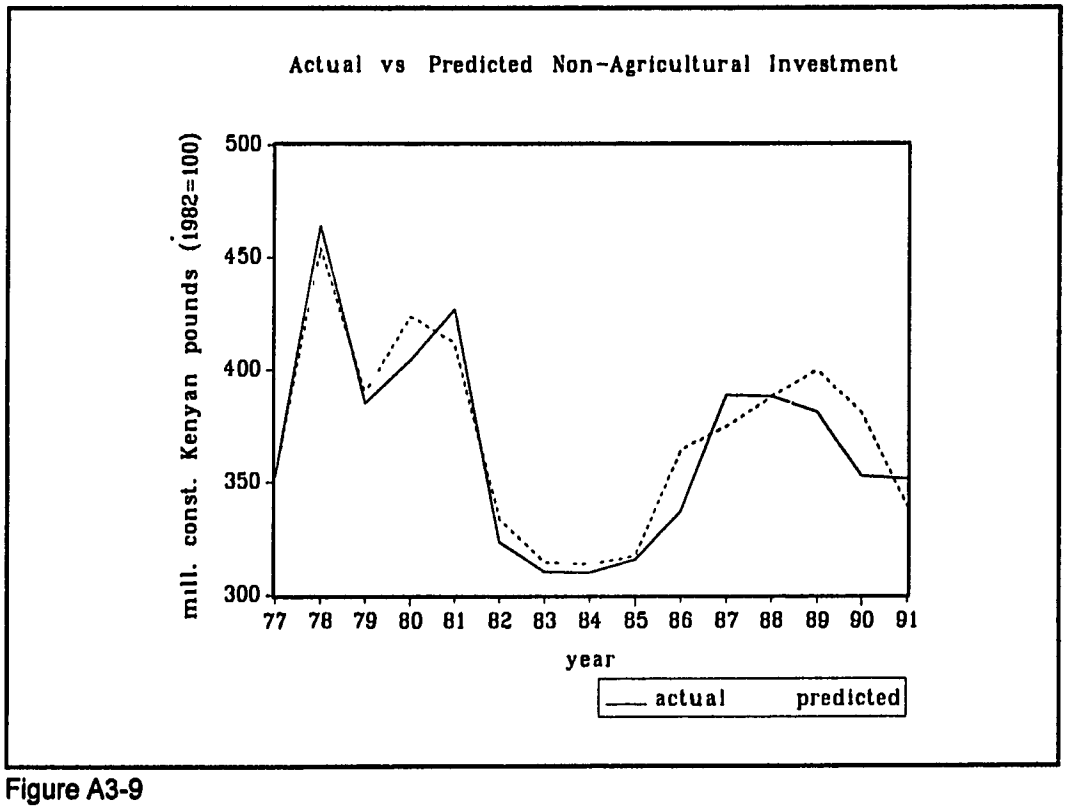

Figure A3-9

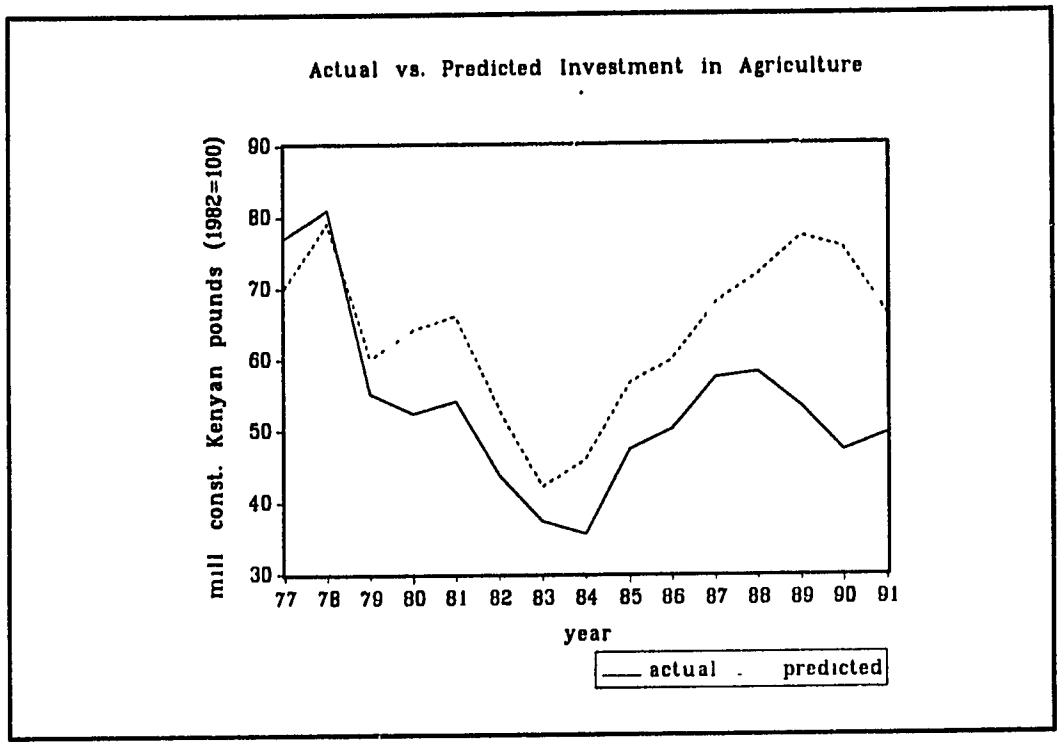

Figure A3-10a

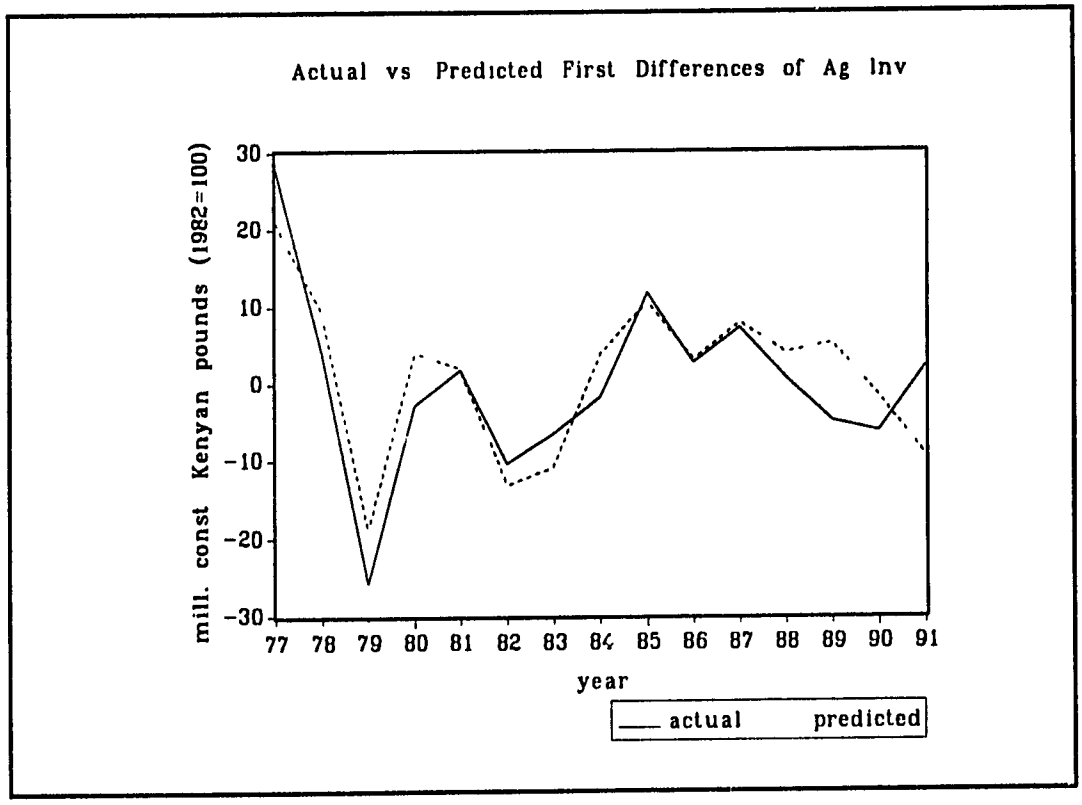

Figure A3-10b

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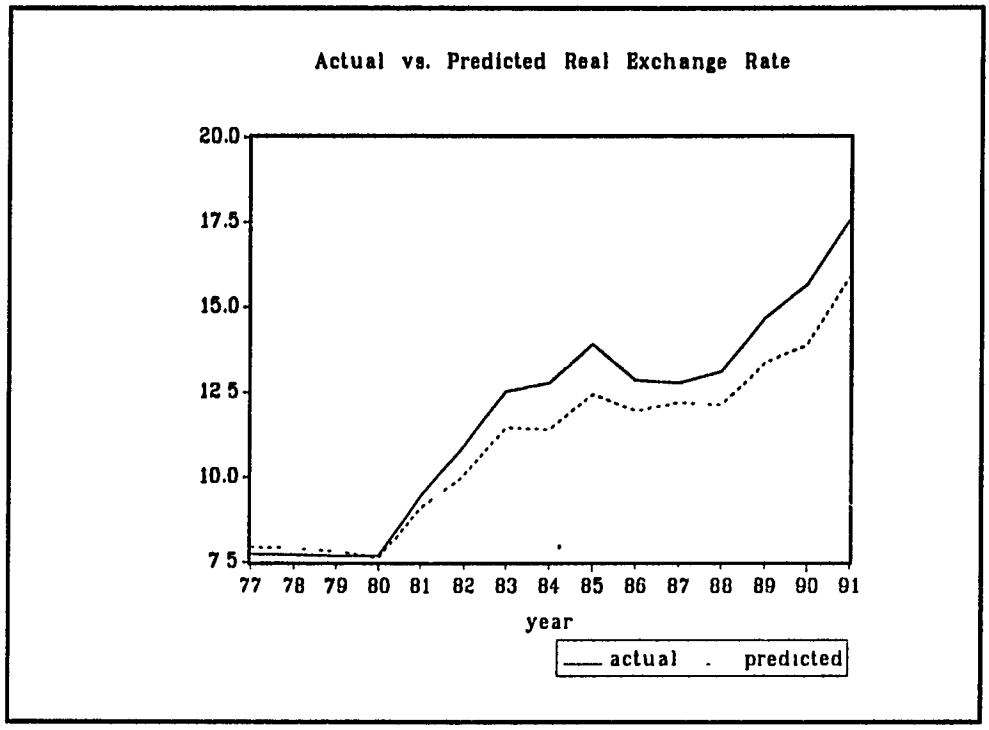

Figure A3-11

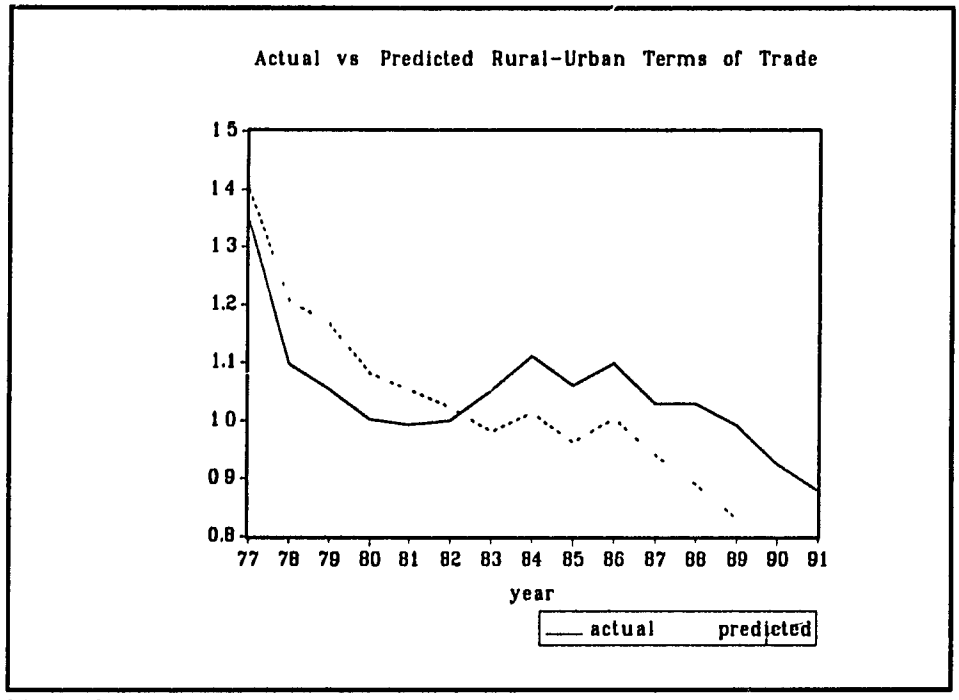

Figure A3-12

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Appendix 3-4

List of Persons Contacted in Kenya

Chris Ackello-Ogutu (University of Nairobi)

John Lynam (Rockefeller Foundation)

Cameron Short (Ministry of Planning)

Robert Keyfitz (Ministry of Planning)

Henry Gordon (private consultant)

Ibrahim Elbadawi (African Economic Research Consortium)

Larry Forgy (AID/REDSO)

Emmy Simmons (AID/REDSO)

Sam Mwale (AID/Kenya)

Maria Mullei (AID/Kenya)

Dennis McCarthy (AID/Kenya)

Tom Hobgood (AID/Kenya)

Chapter 4. Productivity Spill-Overs from Agriculture

The previous chapter demonstrated that agricultural growth in Kenya contributes to non-agricultural growth, and thus has both direct and indirect effects on economic growth in general. The simulation model described above, however, does not explicitly identify the mechanisms through which these contributions operate. The conceptual model outlined in Chapter Two suggests that agriculture's contribution to non-agricultural growth operates in part via externalities resulting from productivity growth in agriculture. This chapter presents an initial effort to measure these "roundabout" linkages in Kenya.

The empirical analysis in this chapter is based on the estimation of production functions for both agriculture and non-agriculture in Kenya. The strategy is to calculate total factor productivity (TFP) in agriculture, and to determine whether the level of agricultural productivity contributes to TFP growth in *non*-agriculture. This empirical approach stops short of specifically measuring the specific non-market linkages described in Chapter Two which enhance agricultural productivity as well as other determinants of non-agricultural productivity. Yet, establishing a statistical relationship between agricultural and non-agricultural TFP makes more explicit the linkages captured broadly in the simulation model, and does so in a manner consistent with the conceptual model outlined in Chapter Two.

The model in Chapter Two posits that non-agricultural productivity is a function of agricultural productivity, as well as of macroeconomic stability and cost competitiveness in non-agriculture. The argument was that particular market failures

both lead to the undervaluation of agriculture and give rise to "roundabout" linkages through which agricultural productivity can contribute to non-agricultural productivity. As described in Chapter Two, the contribution of agricultural productivity growth to growth in non-agriculture stems from at least five sources, including: learning by doing, improved food security and political stability, greater efficiency in decision making as rural enterprises claim a larger share of output, higher productivity of industrial capital as urban bias is reduced, and higher productivity of labor as nutritional standards improve.

Agricultural productivity also contributes to the existence of a competitive cost structure in non-agriculture, which further enhances non-agricultural productivity. A productive agricultural sector contributes to higher capacity utilization in non-agriculture (an element of a competitive cost structure) by stabilizing and increasing both the supply of agriculture-based industrial inputs and the availability of industrial inputs purchased with foreign exchange. In addition, increased agricultural productivity releases labor for industrial employment.

Economic stability also contributes to non-agricultural productivity. This stability takes several forms, including the stability of domestic prices and exports, as well as the stability of the food economy. A more stable macroeconomic environment enhances non-agricultural productivity by facilitating both increased and higher quality capital investments. Food price stability is particularly important in this context. Stable food prices improve conditions for non-agricultural investment because food serves as a wage good, and thus food price stability makes wage bills more

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predictable. Stable food prices also contribute to political stability, which further improves the climate for non-agricultural investment. Increased agricultural productivity can play an important role in stabilizing food prices, particularly in risky agricultural environments such as Kenya's. Thus, like a competitive cost structure, economic stability is both a direct contributor to non-agricultural productivity and itself in part a function of agricultural productivity.

The "Timmer linkages" thus serve both to promote agricultural productivity and to facilitate agricultural productivity's roundabout contributions to non-agricultural productivity by permitting agricultural productivity to contribute to cost competitiveness and economic stability.

In short, the argument is that

$$Y_{nag} = f(K_{nag}, L_{nag}, \lambda_{nag}) \quad (1)$$

where the subscript $_{nag}$ indicates non-agriculture, Y is output (in this case, value added), K is capital stock, L is number of workers, and λ is TFP; and,

$$\lambda_{nag} = f(\lambda_{ag}, \textit{stability}, \textit{cost structure}) \quad (2)$$

As discussed in Chapter 2, available data do not permit measurement of each of these effects. The following empirical results examine only part of functional relationship depicted in equation (2). The focus is on the effects of economic stability and agricultural productivity on non-agricultural productivity.

The proxy for economic stability adopted here is based on the deviations of

actual exports from expected exports as a share of GDP. The actual proxy used for economic instability is the 3-year moving average of $|X_t - X^e| / Y_t$, where X_t is exports in year *t*, X^e is expected exports (calculated as the 5-year moving average of actual exports), and Y_t is GDP in year *t*. Dawe (1993) shows that this is a meaningful proxy for general instability, and that it plays a significant role in explaining rates of economic growth in a cross-section of countries.

Calculating agricultural TFP requires estimation of an agricultural production function. TFP is reflected in vertical shifts in the production function -- that is, by increases in output not accounted for by increases in input use (the latter being represented by shifts *along* the production function). Mathematically, TFP growth is calculated (in logarithms) as the difference between output and a weighted average of the inputs. These weights are estimated econometrically as the production coefficients in the agricultural production function. Thus, given a Cobb-Douglas production function with capital and labor, agricultural TFP is estimated as

$$\lambda_{ag} = \log Y_{ag} - \beta_1 \log K_{ag} - \beta_2 \log L_{ag} \quad (3)$$

Typically, agricultural production functions are also estimated to include land and fertilizers. Given the particular aggregate-level data for Kenya, however, the slow rate of growth in agricultural land area results in negative and insignificant production coefficients for land. Such implausible estimates are best excluded from the production function for purposes of productivity estimation. Similarly, the low levels of fertilizer use (particularly in the earlier years examined), along with the poor

quality of the available fertilizer data, resulted in negative and insignificant production coefficients for fertilizer.[1]

Equation (4) summarizes the results of estimating an agricultural production function for Kenya from 1972-92 (with relevant t-statistics in parentheses). The time trend variable captures the annual rate of agricultural TFP growth, which this estimate suggests grew on average at 0.6% per year over this period.

$$\log Y_{ag} = \underset{(-4.26)}{-1.18} + \underset{(2.84)}{0.414} * \log K_{ag} + \underset{(4.01)}{0.586} * \log L_{ag} + \underset{(5.44)}{0.0058} * time \quad (4)$$

D.W. = 1.44 $\bar{R}^2$ = .98 n = 20

In other words, agricultural output increased by nearly 0.6% per year beyond the amount accounted for by increases in capital and labor. This agricultural production function makes it possible to construct a time series of agricultural TFP which can then be tested as an explanation for productivity growth in non-agriculture. This is done by first estimating a non-agricultural production function with capital and labor. This results in an initial TFP estimate for non-agriculture. By then including agricultural TFP in the non-agricultural production function, the resulting reduction (if any) in the non-agricultural TFP growth rate reflects the contribution of agricultural TFP to non-agricultural TFP. This approach to decomposing non-agricultural TFP

[1] Clearly, there are particular crops and sub-regions within Kenya (the high-potential zones in particular, where this finding is unrealistic. For an aggregate agricultural production function estimated for 1972-92, however, an insignificant coefficient for fertilizer is at least plausible (if not preferable).

can also be extended to include other potential "shift" variables.[2]

The non-agricultural production function is constrained to constant returns to scale. In addition, for more appropriate comparability of the TFP estimates, the production coefficients are also constrained to be equal to the coefficients estimated when agricultural TFP is included in this non-agricultural production function.[3] We can then proceed to apply the meta-production function approach to measure the contribution of both agricultural TFP and economic instability to non-agricultural TFP. Table 4-1 summarizes the meta-production functions for non-agriculture.

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[2] In principle, one could also apply this methodology, know in the literature as a "meta-production function", to explaining agricultural TFP. For present purposes, however, we take agricultural TFP as given, and proceed to examine its role in stimulating non-agricultural output.

[3] When the non-agricultural production coefficients are not constrained to equal those of the second-round estimate, the capital coefficient is unreasonably high, and the implied TFP growth rate 1.29% per year. For purposes of assessing the contribution of agricultural TFP to non-agricultural TFP, the more constrained version is also the more conservative approach in that it minimizes the share of agriculture's contribution.

Table 4-1 Estimated Meta-Production Functions for Non-Agriculture

	Version 1	Version 2	Version 3
constant	.136 (6.87)	.430 (1.09)	.228 (0.56)
capital	.313 (fixed)	.313 (2.58)	.347 (2.47)
labor	.687 (fixed)	.687 (4.95)	.653 (4.64)
Ag TFP_{t-1}	—	.245 (1.42)	.213 (1.50)
instability	—	—	-0.23 (-2.58)
time	.0085 (5.86)	.0067 (3.82)	.0058 (4.21)
AR(1)	.39 (2.70)	.33 (1.93)	.32 (1.91)
$\bar{R}^2$	.997	.996	.998
D.W.	1.37	1.43	2.19
n	18	18	18

t-statistics in parentheses

Version 1 of the non-agricultural production function estimates the function in the absence of any shift variables. Given the constraint described above, version 1 indicates that non-agricultural TFP in Kenya grew at 0.85% per year from 1972 to 1992, somewhat faster than the rate of agricultural TFP growth.

Agricultural TFP enters the specification as a shift variable in version 2. The estimated coefficient is positive though not quite statistically significant.[4] Including this shift variable in the non-agricultural production function reduces the estimated

[4] The coefficient on agricultural TFP in version 2 has P-value = .18.

rate of non-agricultural TFP growth to 0.67% per year (a difference which is highly statistically significant).[5] Thus, an upper bound estimate is that agricultural TFP growth accounts for 21% of non-agricultural TFP growth in Kenya.[6]

Version 3 of the non-agricultural production function includes both agricultural TFP and a proxy for macroeconomic instability as shift variables. As expected, instability has a negative (and highly statistically significant) effect on non-agricultural output. As the addition of the instability proxy to the specification has no significant effect on the estimate for agricultural TFP, we can conclude that the effects of those two shift variables are largely unrelated to one another and hence additive. Thus, economic instability accounts (negatively) for approximately 7% of non-agricultural TFP growth. *Together, agricultural TFP and macroeconomic instability explain nearly one-third of productivity growth in Kenya's non-agricultural sector.*

The specific effect of agricultural productivity can be examined in greater detail. The expression for agricultural TFP in equation (3) incorporates two distinct components in λ_{ag} -- a trend component (which might be termed "pure" TFP), and random shocks (error terms). These distinct components of calculated agricultural TFP have distinct interpretations within our model. The distinction relates to the unpredictability of the random component, which manifests itself as random variation in agricultural output. In particular, these random variations could be an important

[5] The relevant F-score is 6.5, which is significant past the .05 level.

[6] Interpreting this estimate as an upper bound is the conservative approach, in view of the possibility that agricultural TFP is positively correlated with excluded shift variables, and thus biased upward.

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influence on capacity utilization in non-agriculture. For instance, as noted in Chapter Three, Kenya's rural-based non-farm industries depend heavily on agricultural output for their inputs. Variations in agricultural output would thus have direct consequences for capacity utilization in those consumer goods-oriented small-scale industries. These effects would be magnified by the importance of consumption linkages in driving agricultural growth multipliers, found by Lewis and Thorbecke to dominate the growth multiplier for farm-based sectors in the Kutu region of Kenya.[7]

Variations in agricultural productivity would also have direct implications for capacity utilization in capital goods industries. While these industries tend to be much less dependent on agricultural output as a direct source of inputs, they are heavily dependent on imported machinery and inputs. Given agriculture's central role in Kenya's foreign exchange earnings (over half of Kenya's foreign exchange earnings in 1992 were from food and beverage exports), random shocks to agricultural productivity strongly condition the availability of imported industrial inputs.

The data bear out this distinction. The results presented in Table 4-1 are based on the broader definition of agricultural TFP, which incorporates both the trend and random components. In that case (comparing versions 1 and 2), including agricultural productivity in the non-agricultural production function reduces the non-agricultural TFP growth rate from 0.85% per year to 0.67%. When, instead, only the random component of agricultural TFP is included in the non-agricultural production function, non-agricultural TFP falls only to 0.82%. While this effect is not statistically

[7] Lewis and Thorbecke (1992)

significant (e.g., the trend variable in the non-agricultural production function when agricultural TFP is excluded is not significantly different from the same trend term when only the random component of agricultural TFP is included), the difference is at least in the expected direction and of a plausible magnitude.

Further empirical tests of the conceptual model presented in Chapter Two would require more detailed data than are presently available at the national level. Thus, for instance, we are unable to test the proposed "roundabout" contributions of various changes in the rural economy to non-agricultural productivity growth. The results presented here, however, are consistent with the existence of those effects, and directly capture the inter-sectoral impacts of those roundabout effects.

Establishing an intersectoral effect from agriculture to non-agriculture via productivity suggests that the Johnston-Mellor list of five types of intersectoral linkages, while important, is not exhaustive. Thus, previous studies in the linkage literature may have missed this effect (though we make no claim to have statistically identified it as distinct from the more standard list of linkages). Approaching the question from this direction, however, and investigating it in the context of production functions, opens the possibility of measuring the inter-sectoral productivity linkage.

It also follows, both from that literature and from the model presented above, that the contribution of agricultural TFP to non-agricultural TFP would be greater than potential contributions in the reverse direction This is particularly true in the African context, where use of purchased inputs remains relatively low. The data bear out this supposition. Using an analogous procedure to that presented above, non-agricultural

TFP makes no measurable contribution to agricultural TFP.

This analysis of production functions fills in some of the lack of specificity in modelling the mechanisms of inter-sectoral linkage in the simulation model presented in the previous chapter. While that model broadly captured the national income-level effects of inter-sectoral linkages, it was necessarily vague in specifying the relevant mechanisms. Looking more closely at the underlying production functions establishes empirical support for those more specific interactions. In doing so, it also adds a dimension to the existing linkage literature discussed earlier. The following chapter summarizes the broad issues addressed in this study and considers their policy implications.

Chapter 5. Policy Implications and Future Directions

Economic development policies that foster rapid increases in the incomes of the poor while also investing in the public aspects of human capital--nutrition, health, and education--will be the most effective way to break into the cycle of poverty that has gripped many of the world's poorest countries. Lessons from historical experience with the earliest developing countries support this approach, and also suggest more concrete strategies for currently developing countries.[1]

In work on the factors causing the end of hunger and reductions in mortality in Western Europe, Fogel provides strong evidence for the importance of increasing caloric intake to reducing mortality and increasing productivity of the working poor.[2] Using a robust biomedical relationship that links height, body mass, and mortality rates, Fogel calculates that increases in food intake among the British population since the late 18th century contributed substantially to increased productivity and per capita incomes. "Thus, in combination, bringing the ultrapoor into the labor force and raising the energy available for work by those in the labor force explains about 30 percent of the British growth in per capita incomes over the past two centuries (p. 63)."

For very poor countries, raising food intake and improving nutritional status of the most impoverished will be the surest route to breaking the negative cycle of poverty The only sustainable way for these countries to pursue this approach will be to raise agricultural productivity and increase supplies of food. At one level, this approach is not

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[1]Several of these themes appeared in Timmer (1994).

[2]Fogel (1991)

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controversial. Indeed, it would seem to fit naturally into the World Bank's policy recommendations as summarized by Mink:

> The essence of these strategies is to make the best use of that resource which is most available to the poor--their own labor. Policies should therefore not discriminate against agriculture, which is the principal labor-intensive sector, and should provide strong support for agriculture development through the provision of rural infrastructure.[3]

The policies suggested by the model and research presented in this report, however, imply a more aggressive stance on the role of agriculture. The poverty-population-environment spiral that is at the core of concerns about the failure of development to reach the poor can be broken only by government policies that redress urban bias. This bias has existed historically and has deep political roots. To end urban bias requires investing in agriculture beyond the point indicated by commodity prices in world markets. Market failures in the valuation of agricultural commodities, combined with political discrimination against agriculture in poor countries, contribute directly to the "poverty-population-environment problem" because less food is produced domestically than is optimal. Fortunately, these market failures are susceptible to intervention by appropriate government policies. The task of this study has been to provide the rational for these policies, not to identify their specific components.

The role of agriculture in existing strategies for coping with the poverty spiral has been limited largely because of a failure to recognize the importance of direct links

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[3]Mink (1993), p. 32.

between agricultural development, food availability, caloric intake by the poor, and reductions in poverty. Part of these reductions are definitional, of course, because poverty lines are often measured in caloric terms. Yet, raising caloric intake of the poor is very important to their well-being, work productivity, and investment in human capital. Empirical evidence provided by Schultz and Fogel illustrates this importance, but a more general case can also be made.[4]

The case builds on three empirical regularities: the relationship between agricultural growth and poverty alleviation, between increases in domestic food production and improvements in nutrient intake, and between agricultural productivity and productivity growth in the rest of the economy. It has been long established that, for a given level of per capita income, a higher share of GDP originating in agriculture contributes to a more equal distribution of income.[5] An agriculture-driven growth strategy, if it does not sacrifice aggregate growth, will direct a greater share of income to the poor. This is the essential first step in breaking the cycle of poverty.

Next, increases in domestically produced food supplies contribute directly to increases in average caloric intake per capita, after controlling for changes in per capita incomes, income distribution, and food prices.[6] Countries with rapidly increasing food production have much better records of poverty alleviation, perhaps because of changes in the local economics of access to food, changes that are not captured by

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[4]Schultz (1993), Fogel (1991). The original analytical case for this approach appeared in Timmer, Falcon, and Pearson (1983).

[5]Kuznets, 1955, Chenery and Syrquin (1975)

[6] Timmer (1992)

aggregate statistics on incomes and prices. Whatever the mechanisms, intensive campaigns to raise domestic food production, especially through rapid technical change, can be expected to have positive spillover effects on nutrient intake among the poor. This is the second step in breaking the cycle of poverty.

The third step is to ensure that these sectoral gains are sustainable in both environmental and economic dimensions. Ensuring sustainability requires that total factor productivity (TFP) increase for the entire economy. Eventually, TFP growth must provide a substantial share of total growth in per capita incomes. Agriculture has a key role to play at this stage as well. Endogenous growth models are just now providing the theoretical foundations to explain the empirical spillovers observed from growth in agricultural productivity to growth in total factor productivity in the rest of the economy. The logic and empirical results are surprisingly consistent, as the results in Chapters Three and Four indicate, at least in a preliminary way.

The conceptual approach and research presented in this study argue that agriculture has been seriously undervalued by both the public and private sectors in those societies where poverty has remained untouched or even deepened. The root causes of this undervaluation are an urban bias in domestic policies and a set of market failures such that commodity prices often do not send signals with adequate incentives to decision makers.

Countries that have experienced such historically prolonged and deep urban bias will almost certainly have a distorted pattern of investment. Too much public and private capital will be invested in urban areas and too little in rural areas. Too much

capital will be held as liquid and nonproductive investments that rural households use to manage risk. Too little capital will be invested in raising rural productivity.

The entire logic of the urban bias model requires that such distortions result in strikingly different marginal productivities of capital in the two sectors. A new growth strategy, such as the one pursued in Indonesia after 1966, that alters investment priorities in favor of rural growth, should be able to benefit from this disequilibrium in rates of return, at least initially. Such a switch in investment strategy and improved rates of return on capital would increase total factor productivity because of improved efficiency in resource allocation. Statistically, the relationship that can actually be estimated would relate agricultural growth to aggregate economic growth.

This study has provided one approach to estimating this relationship, with highly positive results. However, few of the specific mechanisms that underpin the "Timmer linkages" between growth in agricultural productivity and growth in factor productivity in the non-agricultural economy have been identified by our results for Kenya. Identifying these mechanisms will almost certainly require a new modeling approach that can be applied to a broad cross-section of time series data at the national level. Currently, this approach is thwarted by the lack of time series data on agricultural and non-agricultural capital formation for more than a few countries. The next stage of research must tackle this problem directly if the full set of linkages between agriculture and non-agriculture is to be identified and quantified in a manner suitable for policy makers.

It is not necessary to await further research to identify and measure these linkages, however, for governments to justify a much more positive 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(as it is in most of Sub-Saharan Africa), even the preliminary empirical evidence presented in this report suggests that stimulating its growth will have large economy-wide effects. With better evidence, though, growth-oriented policy makers can be much more persuasive in the halls of political economy in articulating the needs of the rural sector.

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