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ELSEVIER

Agricultural Economics 27 (2002) 7–13

AGRICULTURAL ECONOMICS

www.elsevier.com/locate/agecon

Productivity and economic growth in Kenyan agriculture, 1964–1996

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Received 18 August 1998; received in revised form 1 November 2000; accepted 1 January 2001

Abstract

This paper analyses the patterns of productivity and economic growth in the aggregated Kenyan agriculture between 1964 and 1996. In the 1964–1973 period, the average output growth exceeded 4% but stagnated to an average of 1.2% during 1988–1996. Over the whole period, capital was the most important contributor to output growth. Mean growth rates of intermediate inputs subsequently decreased and were negative in 1988–1996. Labour was the least significant source of growth. The mean total factor productivity growth was less than 0.4% and decreased over time. The contribution of productivity growth to output growth increased from 10.2% in 1964–1973 to 26.8% in 1988–1996. © 2002 Elsevier Science B.V. All rights reserved.

Keywords: Kenya; Agriculture; TFP; Production function; Translog

1. Introduction

This paper analyses productivity growth in the Kenyan agricultural sector between 1964 and 1996. Agriculture is the dominant sector in Kenya, the sector's performance has a large impact on the economy as a whole, and it is a major export sector. The sector also engages a majority of the population, mainly in small-scale farming.

In the past, growth in the agricultural sector emanated mainly from expansion of area under cultivation and transition from low value to high value agricultural activities (Republic of Kenya, 1994). The potential for continued growth from these sources is diminishing rapidly. About 17% of total agricultural land are considered as medium to high potential for rain-fed agriculture production. Although development of Arid and Semi-Arid Lands (ASAL) has received increased attention since the late 1970s, the limited supply and increased difficulties to expand the area of arable land remains a problem. Therefore, to generate high growth in agriculture, the focus has shifted increasingly towards means to increase productivity.

After independence, Kenya adopted an import substitution industrialisation (ISI) strategy for its industrial development. In the early 1970s, the degree of industrial protection was increased substantially. The government also imposed strict price controls and adopted policies, which required producers to buy domestically produced inputs whenever available. As the ISI strategy in general raised manufacturing output prices above international prices, the domestic intermediates were generally more costly than those available in the international market. This made

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PII: S0169-5150(01)00062-7

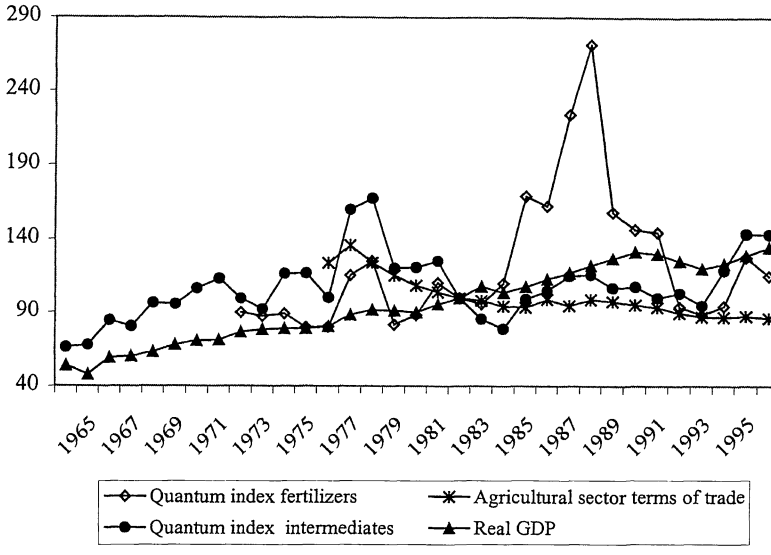

Fig. 1. Selected indices of agricultural production.

agriculture dependent on high-cost inputs produced by the import substitution industries while prices on agricultural commodities were artificially held down by the price controls. Consequently, the agricultural terms of trade has worsened almost continuously since the 1970s.

Importation of agricultural intermediate inputs, such as fertilisers, required prior approval before allocation of foreign exchange. It appears that the import restrictions depressed intermediate use and fertiliser use in particular. The quantities of fertilisers used in agriculture remained almost at the same level from 1972 to 1984. In 1985, the government considerably relaxed the procedures to import fertilisers. Consequently, the quantum index of fertilisers rose substantially from 110 in 1984 to 272 in 1988 (see Fig. 1). However, increasing costs and shortages of foreign exchange, seriously affected the use of fertiliser and other intermediates in the late 1980s and early 1990s. The quantum index of fertilisers fell rapidly from the 1988 level to 88.4 in 1993. Real output growth also fell from 4.1% in 1988 to −3.8% in 1993. Activity in the sector picked up during 1994–1996. The 1994–1996 Development Plan pointed out that the annual fertiliser consumption was considerably below the estimated requirement for a growing agricultural sector. The government also clearly expressed the intention to initiate programmes to increase fertiliser use.

During the 1980s, the problems associated with the ISI strategy became evident and the emphasis gradually shifted toward export promotion. A major policy shift was the introduction of structural adjustment programs. These started in the early 1980s but one might argue that it was not until the late 1980s when the process started to accelerate. Price controls, for example, prevailed until October 1994, when they were finally abolished.

The Kenyan agricultural sector has experienced several shocks and booms. Among these, the most important are the coffee-booms in 1976–1977 and 1986. Agriculture is also vulnerable to climatic conditions. Frequently the sector has been affected by insufficient rainfall and occasionally by droughts, where the drought in 1984 were the most severe.

In what follows, we will consider three different sub-periods in our analysis of productivity and growth in the Kenyan agricultural sector. These are selected to cover the immediate post-independence period (1964–1973), the period following the oil-crisis and the substantially increased protection of domestic industries (1974–1987), and the period of structural adjustment and the shift to export promotion (1988–1996).

2. Data

Data on agricultural output, intermediate inputs and values added during 1964–1971 are taken from Vandemoortele (1984) and 1972–1996 from the Central Bureau of Statistics (Republic of Kenya, various years) publications: Statistical Abstract and Economic Survey. Vandemoortele's series are in constant 1976 prices and have been transformed to 1982 prices. Due to specific data problems, agriculture also includes fishery and forestry.

Output and intermediate inputs are in 1982 constant prices. Since there are no published deflators for output and intermediate inputs for forestry and fishing, the deflators for agriculture has also been used for these sectors.

Labour is the number of workers adjusted for the average hours worked, where data on average hours per week, 1972–1985, was taken from employment and earnings in the modern sector (Republic of Kenya, various years). For the period before 1972, it was assumed that average hours per week was equal to those in 1972. Average hours per week during 1985–1993 was provided by unpublished data from the CBS in Nairobi, and average hours per week in 1994–1996 was assumed equal to those in 1993. The average hours per week was then multiplied by 52 to get average hours worked on annual basis. Capital is the capital stock, constructed using the perpetual inventory method according to

$$K_t = K_{t-1}(1-\delta) + I_t$$

where K_t is the capital stock at time t, δ the depreciation rate and I_t the real investments in period t. Depreciation rates are taken from Wilson et al. (1992). Investments during 1964–1971 are taken from Vandemoortele (1984) and 1972–1996 from Wilson et al. (1992), Wilson (1993) and Statistical Abstract/Economic Survey.

3. Model specification and estimation

To study productivity in Kenyan manufacturing we adopt a production function approach. The translog functional form was chosen to avoid strong restrictions on the technology.

The translog production function specification is defined as

$$\begin{aligned}\ln Y = {} & \alpha_0 + \alpha_X \ln X + \alpha_K \ln K + \alpha_L \ln L + \alpha_T T \\ & + \tfrac{1}{2}\beta_{XX} \ln X^2 + \beta_{XK} \ln X \ln K + \beta_{XL} \ln X \ln L \\ & + \beta_{XT} \ln XT + \tfrac{1}{2}\beta_{KK} \ln K^2 + \beta_{KL} \ln K \ln L \\ & + \beta_{KT} \ln KT + \tfrac{1}{2}\beta_{LL} \ln L^2 + \beta_{LT} \ln LT \\ & + \tfrac{1}{2}\beta_{TT} T^2 \end{aligned} \quad (1)$$

where Y is the output, X the intermediate inputs, K the capital, L the labour and T the time. The function is symmetric such that $\beta_{ij} = \beta_{ji}$.

We also assume that production is characterised by constant returns to scale. Under constant returns to scale, the value share for each input in the value of output are equal to the elasticity of output with respect to that input and the value shares sum up to unity. Given the functional form defined in Eq. (1) we define the value shares as

$$\begin{aligned} \nu_X &= \alpha_X + \beta_{XX} \ln X + \beta_{XK} \ln K + \beta_{XL} \ln L + \beta_{XT} T, \\ \nu_K &= \alpha_K + \beta_{XK} \ln X + \beta_{KK} \ln K + \beta_{KL} \ln L + \beta_{KT} T, \\ \nu_L &= \alpha_L + \beta_{XL} \ln X + \beta_{KL} \ln K + \beta_{LL} \ln L + \beta_{LT} T \end{aligned} \quad (2)$$

The translog function is characterised by constant returns to scale if and only if the parameters satisfy the conditions

$$\begin{aligned} &\alpha_X + \alpha_K + \alpha_L = 1, \qquad \beta_{XX} + \beta_{XK} + \beta_{XL} = 0, \\ &\beta_{XK} + \beta_{KK} + \beta_{KL} = 0, \qquad \beta_{XL} + \beta_{KL} + \beta_{LL} = 0, \\ &\beta_{XT} + \beta_{KT} + \beta_{LT} = 0 \end{aligned} \quad (3)$$

The complete model, as outlined above, consists of the output equation (Eq. (1)) and the three share-equations (Eq. (2)) set up to be solved as a simultaneous equation system. Since the sum of the value shares always equals one, only $n-1$ of the value shares are linearly independent. This implies that the disturbance covariance matrix is singular and non-diagonal (Berndt, 1991). To solve the singularity problem, the labour equation (ν_L) is arbitrarily dropped from the estimation. The parameter estimates and their variances from the dropped equation can be derived by indirect estimation. This set of seemingly unrelated equations, Eqs. (1) and (2) is solved using

Table 1
Parameter restriction tests

	LR-test statistics	d.f.	$\chi^2_{(0.05)}$
Hicks neutrality	8.89	2	5.99
Separability	17.75	3	7.81
Piece-wise separability *XK–L*	8.93	2	5.99
Piece-wise separability *KL–X*	15.40	2	5.99
Piece-wise separability *XL–K*	12.90	2	5.99
Piece-wise non-linear separability *XK–L*	17.78	3	7.81
Piece-wise non-linear separability *KL–X*	22.74	3	7.81
Piece-wise non-linear separability *XL–K*	14.68	3	7.81

Zellner's iterative seemingly unrelated regression (ITSUR) procedure in SAS.

The resulting Durbin–Watson (DW) statistics from preliminary estimations suggested that auto-correlation was a problem. To solve this problem an auto-regressive mechanism was induced. The problem associated with presence of auto-correlation is that the parameter estimates are no longer invariant to the choice of equation dropped. Trial estimations suggest that, although not identical, the results were not substantially altered when alternating share equation dropped. However, when alternating share equations dropped, there was a convergence problem.

The specification outlined above was tested for separability. In simplicity, separability addresses the question if the marginal rate of rate of substitution between input i and j are independent of the quantities of input k. As a first test, global separability was tested. If global separability was rejected, the second test was for piece-wise linear separability between any two pairs of inputs and, finally, we tested for piece-wise non-linear separability (see Berndt and Christensen, 1973). All types of separability were rejected. The test results are presented in Table 1.

As part of the estimations, price elasticities were also calculated. These provide a measure of the effects of a percentage change in the price of input i on the demand for input j. The price elasticities are defined as $\varepsilon_{ij} = S_j\sigma_{ij}$, where S_j is the estimated value-share of the jth input and σ_{ij} is the partial Allen elasticity of substitution. We define the Allen elasticity as $\sigma_{ij} = \sum_{h=1}^{n} F_h X_h |\bar{F}_{ij}|/X_i X_j |\bar{F}|$ where $|\bar{F}|$ is the determinant of the bordered Hessian, and $|\bar{F}_{ij}|$ is the cofactor of F_{ij} in $\bar{F}$. The price elasticities might be useful to analyse the effects of price changes on input demand since public policies were largely pricing policies.

Finally, total factor productivity (TFP) growth is measured by a Törnqvist index. The Törnqvist index has been shown an exact and superlative index and a suitable discrete time approximation to the continuous time Divisia-index (Diewert, 1976). This index has been widely used especially when the translog specification is considered. Between any two consecutive time periods, t and $t+1$, the Törnqvist-index is calculated (in log form) as

$$\mathrm{TFP}_{t,t+1} = \ln Y_{t+1} - \ln Y_t - \sum_i \frac{1}{2}[S_{i,t+1} + S_{i,t}] \times [\ln X_{i,t+1} - \ln X_{i,t}] \quad (4)$$

where S_i denotes the respective input's value-shares.

The Törnqvist index requires that the shares result in perfect aggregation. This is ensured by the assumption of constant returns to scale.

4. Results of parameter estimation

Table 2 presents the results from the parameter estimation. R^2-adjusted were 0.95 for the output equation, 0.58 for the capital share equation and 0.66 for the

Table 2
Parameter estimates

Parameters	Estimate	S.E.	Parameters	Estimate	S.E.
α_X	0.128	0.004	β_{XT}	−0.002	0.0003
α_K	0.772	0.005	β_{KK}	−0.037	0.027
α_L	0.100	0.004	β_{KT}	0.002	0.0005
α_T	0.004	0.003	β_{LK}	0.068	0.018
β_{XX}	0.056	0.013	β_{LL}	−0.044	0.0136
β_{XK}	−0.031	0.014	β_{LT}	−0.0002	0.0003
β_{LX}	−0.025	0.008	β_{TT}	−0.00005	0.0005

intermediate share equation. Durbin–Watson statistics were 1.68 for the output equation, 1.81 for the capital share-equation and 2.10 for the intermediate share-equation.

α_T can be interpreted as the point estimate of productivity growth and α_{TT} as the acceleration of productivity growth. In agriculture, both productivity growth and the acceleration of productivity growth were neutral (not significant). The β_{iT} parameters indicate the biases of productivity growth. Productivity growth was intermediate saving, capital using, and labour neutral (not significant).

5. Price elasticities

Table 3 presents the mean values of the own and cross price elasticities for overall mean and the selected sub-periods.

The mean own-price elasticity for intermediate input was high, −1.97, while the labour and, in particular, capital own-price elasticities were relatively low. The own-price elasticity for intermediate input increased particularly during 1988–1996 (see Table 3). Cross price-elasticities suggest that a percentage change in the price of intermediate input would have a large effect on demand for capital while only a modest effect on demand for labour. The low own-price elasticities for both labour and capital suggest low substitution possibilities for both these inputs. Demand responses from a change in capital prices were particularly low in labour, close to zero.

The high elasticity for intermediate input might be surprising in a sense since one would normally expect that intermediates such as fertilisers, seeds, and similar items are essential in agriculture and not easily substituted.

Due to the seasonality in agriculture and agricultural incomes, the planning problem is particularly difficult in agriculture. There is also a need to have certain inputs such as seeds, fertilisers and other similar inputs, available at the right time. Therefore, agriculture is highly vulnerable to unanticipated cost increases. Many Kenyan farmers are also dependent on the international market prices. Prices on the international markets have often fluctuated, affecting some of the major crop in Kenya, such as coffee and tea.

To add to this problem, the government policies, which required farmers to buy domestically produced inputs, although cheaper inputs were available on the international market, is likely to have affected agriculture. Import restrictions and the frequent shortages of foreign exchange might have limited the ability to import essential intermediates that where not available on the domestic market. At the same time, price controls are likely to have made it difficult for farmers to get compensation for the increased costs, as suggested by the falling agricultural terms of trade. The availability of agricultural credit facilities has also been limited farmers. Together with the stagnation in output growth, these factors are likely to have made it increasingly more difficult for farmers to meet the increased costs of intermediates.

As suggested by the price-elasticities, intermediate use was substantially decreased when the intermediate prices escalated in the late 1980s and early 1990s.

Table 3
Mean values of price elasticities

Elasticities	Mean	1964–1973	1974–1987	1988–1996
ε_{KK}	−0.25	−0.25	−0.25	−0.26
ε_{XX}	−1.97	−1.80	−1.80	−2.44
ε_{LL}	−0.68	−0.66	−0.68	−0.72
ε_{XK}	1.55	1.45	1.43	1.86
ε_{KX}	0.24	0.24	0.24	0.24
ε_{XL}	0.42	0.35	0.38	0.58
ε_{LX}	0.58	0.59	0.54	0.62
ε_{LK}	0.10	0.07	0.13	0.10
ε_{KL}	0.01	0.01	0.02	0.01

6. Output growth and TFP

Table 4 presents the average annual growth rates of output and the weighted growth rates of intermediate, capital, and labour inputs and TFP growth.

In agriculture, the mean growth rates of output decreased over time. Initially, the establishment of individual ownership and large land-transfer programmes enabled an expansion of land under cultivation and a transition from low value to high value agricultural activities. Besides, the build-up of the industrial sector and the generally high level of economic activity, which prevailed throughout the economy during the 1960s, stimulated agricultural production. Afterwards,

Table 4
Average annual growth rates of output and weighted growth rates of inputs and productivity growth (%)

	Output growth	Intermediate inputs	Capital inputs	Labour inputs	Productivity growth
Mean	2.80	0.34	2.04	0.06	0.36
1964–1973	4.10	0.82	2.74	0.12	0.42
1974–1987	2.99	0.51	2.17	−0.05	0.36
1988–1996	1.22	−0.40	1.13	0.16	0.32

expansion of the agricultural sector became more problematic.

Agriculture was affected by the protectionist measures taken by the government in response to the economic difficulties the economy ran into in the early 1970s. Later, the economic difficulties became aggravated, including frequent foreign exchange crises, which affected the whole economy. Agriculture was also affected by the fluctuations in international trade. Since the limited supply of arable land made expansion of agricultural land increasingly more difficult, growth would increasingly have to come from increases in productivity. However, productivity growth has been relatively low and increased on average by less than 0.4% per year. Our results also show that productivity growth has decreased over time, although its contribution to output growth increased from 10.2% in 1964–1973 to 26.8% in 1988–96. One possible explanation for the low levels of productivity growth might be the low level of fertilisers and other inputs, which would have a direct effect on the productivity of land, used in agriculture. At least if we consider the substantially increased level of fertiliser use, which occurred in the 1985–1988 period after the relaxation of import restrictions. If the level of fertiliser use during this period reflects the level needed in agriculture, fertiliser use has been less than half of the level needed for most of the period. Therefore, it appears that there are potential gains in productivity and growth by increased level of fertiliser use. Besides, frequent adverse climatic conditions have also affected agriculture. The drought in 1984 seriously affected the sector but inadequate rainfalls have also affected agricultural production, especially during the late 1980s and early 1990s.

Overall, capital was the clearly dominant source of output growth in agriculture, while labour growth was the least significant contributor to output growth (see Table 4).

The average capital growth rates where high in both the 1964–1973 and the 1974–1987 periods but decreased substantially during 1988–1996. Labour growth fell and was negative in the 1974–1987 period but increased in 1988–1996 period.

Mean growth rates of intermediate inputs has subsequently decreased over the sub-periods. Import restrictions and lack of foreign exchange might be the major reason for the falling growth rates of intermediate inputs during the 1970s up to the mid-1980s. In the 1988–1996 period, the mean growth rates were even negative essentially a consequence of the generally rapid increases in intermediate prices in this period.

7. Conclusion

This paper has analysed the patterns of productivity and economic growth in the aggregated Kenyan agriculture, 1964–1996.

In agriculture output growth stagnated over time. While average output growth exceeded 4% in the 1964–1973 period, the average output growth during 1988–1996 had fallen to 1.2%. This was well below the population growth, approximately 3%, and might indicate a matter of concern given the expressed goal of self-sufficiency in food and food security.

Over the whole period, capital was the most important contributor to output growth. In particular, capital growth was high in both the 1964–1973 and 1974–1987 period but decreased substantially in the 1988–1996 period. Mean growth rates of intermediate inputs subsequently decreased and were negative in 1988–1996. Labour was the least significant source of growth.Total factor productivity growth decreased over time in agriculture. Its contribution to output growth, however, increased from 10.2% in 1964–1973 to 26.8% in 1988–1996. On average, productivity growth increased by less that 0.4% per year. One

major source of the low productivity might be the low level of fertiliser use. The low level of productivity might also stem from a multitude of other factors, some of which are difficult to trace. It might have been affected by poor extension services, perhaps inability to upgrade production methods, physical and human capital. Agriculture has also been affected by limited access to agricultural credits and shortages of foreign exchange. Public policies during the import substitution era might also have overemphasised industrial expansion and allocated resources to the industrial sector in disproportion to other sectors, thereby affecting agriculture.

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