Agricultural Prices and Supply Response in Tropical Africa

Osman Sed Elmi

Department Of Agricultural Economics

McGill University, Montreal

1994

A Thesis Submitted to the

Faculty of Graduate Studies and Research

in Partial Fulfilment of the Requirements of the degree of

Master of Science in Agricultural Economics

Name Sed-Elmi Osman

Dissertation Abstracts International is arranged by broad, general subject categories. Please select the one subject which most nearly describes the content of your dissertation. Enter the corresponding four-digit code in the spaces provided.

Economics Agricultural — SUBJECT TERM

0503 — SUBJECT CODE

U·M·I

Subject Categories

THE HUMANITIES AND SOCIAL SCIENCES

COMMUNICATIONS AND THE ARTS

Architecture	0729
Art History	0377
Cinema	0900
Dance	0378
Fine Arts	0357
Information Science	0723
Journalism	0391
Library Science	0399
Mass Communications	0708
Music	0413
Speech Communication	0459
Theater	0465

EDUCATION

General	0515
Administration	0514
Adult and Continuing	0516
Agricultural	0517
Art	0273
Bilingual and Multicultural	0282
Business	0688
Community College	0275
Curriculum and Instruction	0727
Early Childhood	0518
Elementary	0524
Finance	0277
Guidance and Counseling	0519
Health	0680
Higher	0745
History of	0520
Home Economics	0278
Industrial	0521
Language and Literature	0279
Mathematics	0280
Music	0522
Philosophy of	0998
Physical	0523
Psychology	0525
Reading	0535
Religious	0527
Sciences	0714
Secondary	0533
Social Sciences	0534
Sociology of	0340
Special	0529
Teacher Training	0530
Technology	0710
Tests and Measurements	0288
Vocational	0747

LANGUAGE, LITERATURE AND LINGUISTICS

Language	
General	0679
Ancient	0289
Linguistics	0290
Modern	0291
Literature	
General	0401
Classical	0294
Comparative	0295
Medieval	0297
Modern	0298
African	0316
American	0591
Asian	0305
Canadian (English)	0352
Canadian (French)	0355
English	0593
Germanic	0311
Latin American	0312
Middle Eastern	0315
Romance	0313
Slavic and East European	0314

PHILOSOPHY, RELIGION AND THEOLOGY

Philosophy	0422
Religion	
General	0318
Biblical Studies	0321
Clergy	0319
History of	0320
Philosophy of	0322
Theology	0469

SOCIAL SCIENCES

American Studies	0323
Anthropology	
Archaeology	0324
Cultural	0326
Physical	0327
Business Administration	
General	0310
Accounting	0272
Banking	0770
Management	0454
Marketing	0338
Canadian Studies	0385
Economics	
General	0501
Agricultural	0503
Commerce Business	0505
Finance	0508
History	0509
Labor	0510
Theory	0511
Folklore	0358
Geography	0366
Gerontology	0351
History	
General	0578
Ancient	0579
Medieval	0581
Modern	0582
Black	0328
African	0331
Asia, Australia and Oceania	0332
Canadian	0334
European	0335
Latin American	0336
Middle Eastern	0333
United States	0337
History of Science	0585
Law	0398
Political Science	
General	0615
International Law and Relations	0616
Public Administration	0617
Recreation	0814
Social Work	0452
Sociology	
General	0626
Criminology and Penology	0627
Demography	0938
Ethnic and Racial Studies	0631
Individual and Family Studies	0628
Industrial and Labor Relations	0629
Public and Social Welfare	0630
Social Structure and Development	0700
Theory and Methods	0344
Transportation	0709
Urban and Regional Planning	0999
Women's Studies	0453

THE SCIENCES AND ENGINEERING

BIOLOGICAL SCIENCES

Agriculture	
General	0473
Agronomy	0285
Animal Culture and Nutrition	0475
Animal Pathology	0476
Food Science and Technology	0359
Forestry and Wildlife	0478
Plant Culture	0479
Plant Pathology	0480
Plant Physiology	0817
Range Management	0777
Wood Technology	0746
Biology	
General	0306
Anatomy	0287
Biostatistics	0308
Botany	0309
Cell	0379
Ecology	0329
Entomology	0353
Genetics	0369
Limnology	0793
Microbiology	0410
Molecular	0307
Neuroscience	0317
Oceanography	0416
Physiology	0433
Radiation	0821
Veterinary Science	0778
Zoology	0472
Biophysics	
General	0786
Medical	0760

EARTH SCIENCES

Biogeochemistry	0425
Geochemistry	0996
Geodesy	0370
Geology	0372
Geophysics	0373
Hydrology	0388
Mineralogy	0411
Paleobotany	0345
Paleoecology	0426
Paleontology	0418
Paleozoology	0985
Palynology	0427
Physical Geography	0368
Physical Oceanography	0415

HEALTH AND ENVIRONMENTAL SCIENCES

Environmental Sciences	0768
Health Sciences	
General	0566
Audiology	0300
Chemotherapy	0992
Dentistry	0567
Education	0350
Hospital Management	0769
Human Development	0758
Immunology	0982
Medicine and Surgery	0564
Mental Health	0347
Nursing	0569
Nutrition	0570
Obstetrics and Gynecology	0380
Occupational Health and Therapy	0354
Ophthalmology	0381
Pathology	0571
Pharmacology	0419
Pharmacy	0572
Physical Therapy	0382
Public Health	0573
Radiology	0574
Recreation	0575
Speech Pathology	0460
Toxicology	0383
Home Economics	0386

PHYSICAL SCIENCES

Pure Sciences

Chemistry	
General	0485
Agricultural	0749
Analytical	0486
Biochemistry	0487
Inorganic	0488
Nuclear	0738
Organic	0490
Pharmaceutical	0491
Physical	0494
Polymer	0495
Radiation	0754
Mathematics	0405
Physics	
General	0605
Acoustics	0986
Astronomy and Astrophysics	0606
Atmospheric Science	0608
Atomic	0748
Electronics and Electricity	0607
Elementary Particles and High Energy	0798
Fluid and Plasma	0759
Molecular	0609
Nuclear	0610
Optics	0752
Radiation	0756
Solid State	0611
Statistics	0463

Applied Sciences

Applied Mechanics	0346
Computer Science	0984
Engineering	
General	0537
Aerospace	0538
Agricultural	0539
Automotive	0540
Biomedical	0541
Chemical	0542
Civil	0543
Electronics and Electrical	0544
Heat and Thermodynamics	0348
Hydraulic	0545
Industrial	0546
Marine	0547
Materials Science	0794
Mechanical	0548
Metallurgy	0743
Mining	0551
Nuclear	0552
Packaging	0549
Petroleum	0765
Sanitary and Municipal	0554
System Science	0790
Geotechnology	0428
Operations Research	0796
Plastics Technology	0795
Textile Technology	0994

PSYCHOLOGY

General	0621
Behavioral	0384
Clinical	0622
Developmental	0620
Experimental	0623
Industrial	0624
Personality	0625
Physiological	0989
Psychobiology	0349
Psychometrics	0632
Social	0451

Agricultural Prices and Supply Response in Tropical Africa

Abstract

The objective of this thesis is to examine price performance, and estimate the aggregate export and food crop output response to output price and non-price variables in tropical Africa and its four main agro-climatic regions. The analysis of real producer prices indicates that there are more countries that exhibited a statistically significant decrease in real producer prices than a significant increase. Moreover, nominal protection coefficient analysis shows that African crop exporters, on average, received a small proportion (50 to 60 percent) of border prices. Using pooled cross-section and time series data, a partial adjustment model was then specified to estimate agricultural export and food output response. The results show that aggregate agricultural export and food supply responses to output prices in tropical Africa are both positive and significant but inelastic. The price elasticity for the export crop output in Tropical Africa is 0.02 in the short run and 0.04 in the long run, and for the food crop output 0.05 in the short-run and 0.07 in the long-run. The responsiveness of agriculture varies, however, across the main agro-climatic regions in tropical Africa. The estimated coefficient of the price variable and price elasticity estimates regions reveal that producers in the Eastern and Southern Africa, and Western Africa regions were responsive to price incentives, while producers in the semi-arid Sudano Sahel and Central Africa regions were not. The trend variable, as proxy of technology, is positive and significant in most regions, suggesting that the provision of non-price factors along with favourable price incentives, could be very effective in raising agricultural production in these regions.

Résumé

L'objectif de cette thèse est d'examiner la performance des prix et d'estimer l'impact de l'offre agricole par rapport au prix et d'autres variables non liés aux prix, sur l'ensemble des produits exportés et les produits non-exportés des principales régions agro-climatiques de l'Afrique L'analyse des prix indique qu'il y a plus de pays qui subissent des diminutions de prix réels de production, que d'augmentations De plus, l'analyse du coefficient nominal de protection démontre que les exportateurs agricoles africains reçoivent des prix intérieurs équivalant de 50 à 61 pour cent des prix frontaliers. Un modèle d'ajustement partiel utilisant un ensemble de données en coupe transversale et de série chronologique a été mis au point afin d'estimer les impacts des politiques sur les exportations agricoles et la production alimentaire Les résultats significatifs démontrent que l'élasticité d'offre pour les exportations agricoles et les cultures alimentaires est positive, mais cependant relativement inélastique. L' élasticité prix pour la production agricole des produits exportés en Afrique tropicale est de 0.02 à court-terme et comparativement à 0 04 à long-terme Pour ce qui est de la production agricole des produits non-exportés, l'élasticité est de 0.05 à court terme alors qu'elle est de 0.07 à long terme L'impact des politiques visant à stimuler la production alimentaire varie cependant d'une région à l'autre et même à l'intérieur de la principale région agro-climatique de l'Afrique tropicale. L'estimation des coefficients pour les prix au producteur et pour l'élasticité démontre que les producteurs de l'Afrique de l'est, du sud et de l'ouest sont incités à la production par

des prix avantageux, contrairement aux producteurs de la région soudanaise sahelienne et de l'Afrique centrale. Le modèle mis au point indique que l'évolution du temps, une mesure de l'évolution technologique, ainsi que des prix favourables, sont des facteurs importants qui contribuent à augmenter la production alimentaire.

ACKNOWLEDGMENT

I take a special pleasure in this opportunity to thank many people who helped me with this thesis. I would like to extend my special thanks to Dr. K. Gunjal, who supervised the study, and provided financial assistance and guidance throughout my programme at McGill university.

I also like to thank Dr. John Henning for the valuable suggestions and comments. Agricultural Economic Department and the McGill student aid office provided me the financial assistance. Dr. Kisan Gunjal and Dr. Paul Thomassin deserve my gratitude for arranging this assistance.

I also express a special gratitude to my family, for their encouragement and wise counsel. I express my appreciation to Suzette Wilshire for her assistance and companionship. Thanks are also due to my colleagues in this Department. Mark Banik and K. Zanoko (for writing the resume), and Ms. K. Patterson, Ms. J. Rop and Mr. G. Lussier (for reading the first draft), and Janet Broxup for her help in editing the final draft of the thesis.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.0 Problem Statement

Agriculture is the cornerstone of African economies, in terms of providing employment and generating foreign exchange earnings (African Development Bank, 1990). Despite the relative importance of this sector, tropical Africa[1] has had a poor agricultural performance. It has experienced a declining per capita food production and a falling world market share of main agricultural export commodities since the 1970s (World Bank,1989). As a result, Africa's foreign earnings have deteriorated while food imports have skyrocketed during this period.

Government intervention in agricultural markets has been cited as the main cause of the agricultural crisis. African governments have established marketing boards that regulated agricultural markets by setting producer prices of the main food crops to subsidize urban consumers. The boards have also imposed high taxes on agricultural exports to generate revenue for the industrialization process (Hanrahan and Christensen,1981; Ghai and Smith,1987). Various studies have indicated that these policy measures distorted producer price incentives and as a consequence, reduced agricultural production (World Bank, 1981,1986).

The impact of price distortion resulting from government intervention depends on the manner in which producers respond to policy measures and how government tax

---

[1] Tropical Africa is also called Sub-Saharan Africa.

revenues collected from the agricultural sector are used. Thus the responsiveness of farmers to price incentives becomes an important issue in the literature of the supply response. Considerable effort by researchers has been directed towards examining the supply response of the main individual crops in tropical Africa. Most empirical studies have shown that farmers in the region do respond positively to price incentives (Bond,1983; Binswagner,1989). This evidence relates to the efficient allocation and use of resources in the agricultural sector. On the other hand, the aggregate agricultural supply response to output price is crucial for optimal resource allocation between sectors. There is, however, little evidence on the aggregate supply response to price. The absence of empirical evidence on the aggregate agricultural supply in tropical Africa may be related to a lack of sufficient information on African agricultural markets (Lele,1989).

The main purpose of the study is to examine how government intervention in agricultural markets affects producer price incentives and agricultural production in tropical Africa.

1.1 Objective of the Thesis

The main objectives of the thesis are:

1. To examine the recent agricultural performance and discuss the main factors contributing to current agricultural problems.
2. To evaluate the trends of real producer prices of primary export crops and staple crops and to calculate the degree of price distortion of export crops arising from government intervention in a selected sample of tropical African countries.
3. To estimate the agricultural supply response to price and non-price variables in

tropical Africa and the main agro-climatic regions.

4. To assess the relative importance of price and non-price variables in explaining the agricultural production in tropical Africa.

5. To assess and compare the inter-regional differences in the agricultural supply response using a common estimation approach and variable specification.

6. To discuss the policy implications of the results.

1.2 Organization of the Thesis

This study examines the responsiveness of African agriculture to price and non-price factors. This chapter introduces the problem statement and presents the objectives of the thesis. Chapter two deals with the importance, main characteristics and performance of African agriculture. Moreover, it discusses government intervention in the agricultural sector. Chapter three discusses the methods used to assess price performance over time and price distortions in the agricultural sector. This chapter also reviews the literature on supply response to price and non-price factors. The studies on individual as well as aggregate supply response are surveyed to reach conclusions needed for model specification. Chapter four discusses econometric techniques relating to the combination of cross section and time series data. It also discusses specification tests used to identify the source and behaviour of the output variations Chapter five specifies the econometric panel data model used to estimate the responsiveness of African agriculture. Chapter six presents the performance of producer prices over time and price distortions on the main export crops in a selected sample of African countries. Chapter seven reports the results of the estimates of the aggregate agricultural supply response to price and non-price factors in the food and export sectors in tropical Africa and four agro-climatic regions. Finally, chapter eight summarizes the main findings and provides the conclusion of the study.

CHAPTER 2

OVERVIEW OF TROPICAL AFRICAN AGRICULTURE

2.0 Introduction

This chapter provides an overview of the role of agriculture in African economies and government involvement in the agricultural sector. Section 1 focuses on the importance of agriculture in African economies. The structure of African agriculture is featured in section 2, is followed by a descriptive analysis of agricultural export and food production over the 1970-1990 period in section 3. Government intervention in agricultural markets is discussed in section 4.

2.1 Importance of Agriculture in African Economy

Agriculture is the dominant sector of African economies. On average, it accounts for over 65 percent of gross domestic product (GDP), provides direct and indirect employment for over 60 percent of the economically active population and contributes from 50 to 60 percent of exports (African Development Bank, 1990). A successful agricultural program is therefore the cornerstone of a recovery strategy for agriculture and other sectors for many countries in the region. According to the seminal paper "The Role of Agriculture in Economic Development" by Johnston and Mellor (1961), there exist at least five direct roles that agriculture can contribute in a developing economy: (1) agriculture can provide food for the people, (2) it can generate foreign exchange through agricultural trade, hence contributing to the balance of payments, (3) it can also transfer excess labour and capital to non agricultural sectors, (4) it can raise the income of rural inhabitants, thereby, increasing the demand of non-agricultural inputs, and (5) it can increase the rate of the capital accumulation required for the promotion of a vibrant industrial base.

2.2 Characteristics of African Agriculture

According to the 1992 World development report, tropical African countries (forty-six) have a population of about 500 million and occupy a total area of 2184 million hectares. The arable land is estimated to be about 816 millions hectares whereas only 25 percent of the area is currently used for agriculture, so the agricultural land reserve for the region as a whole is high (see Table 2.0). The structure of African agriculture can be characterized as a dualistic: small-scale peasant farms and large-scale estate farms. Most of the farmers in tropical Africa are small-scale farmers (farming from 2 to less than 10 hectares), occupying about 80 percent of the landholding on the continent (Eicher et al,1990, pp.41). Small-scale farmers produce staple food crops mainly for home consumption and some surplus produce for marketing. In the smallholder farming, family labour is the main input of agricultural production while purchased inputs are very low. Estate farms and large plantations constitute about 20 percent of landholdings in Africa. In general, the large-scale farms are more capital-intensive than the smallholder farms. The large-scale farms produce both cash and food crops for export as well as for local markets.

Although tropical African countries have similar economic structure, they differ in their climatic conditions and natural resources. Variable rainfall is the primary cause for the variability of the agro-climate, since temperature is generally high throughout the year.

Table 2.0 Agricultural Resource and Input Use in Tropical Africa and Four Main Agro-climatic Regions

Agro-climatic Regions[a]	Arable Land Potential (mill ha)	Arable Land In Use % of Potential	Irrigated Area[b] (%)	Fertilizer Consumption (Kg/ha)	Agricultural Tractors (number of per 1000 ha)	Agric Labour Force (ha/Units)
	1987	1987	1980-87	1987	1982-87	1987
Sudano-sahel	123 9	57 4	8 4	4 1	0 7	2 8
Western Afr a	95 5	52 5	2.3	6 1	1 6	2 0
Central Africa	286 1	17 8	0 7	1 9	0 7	2 5
East and southern Africa	306 0	47 4	6 1	13 1	3 6	1 4
Tropical Africa	815 7	25 0	4 3	11 3	1 7	2 2

a The Sudano-Sahel (or semiarid Sudano-Sahel) region includes Burkina Faso, Cape Verde, Chad, The Gambia,Mali, Mauritania, Niger, Senega,l Somalia and Sudan

Western Africa is Humid and semi-arid Western Africa The Western Africa countries include Benin, Cote d'Ivoire, Ghana, Guinea, Guinea Bissau, Liberia, Nigeria, Sierra Leone and Togo

Central Africa (or Humid Central Africa) region includes Cameroon, Central Africa Rep Congo, Equatorial Guinea, Gabon and Zaire

East and Southern Africa (or Sub-humid East and Southern Africa) region includes Burundi,Ethiopia, kenya, madagascar, Mauritius, Rwanda, Uganda, Angola, Botswana, Lesotho, Malawi, Mozambique, Swaziland, Tanzania, Zambia and Zimbabwe

Tropical Africa is the total of these four regions

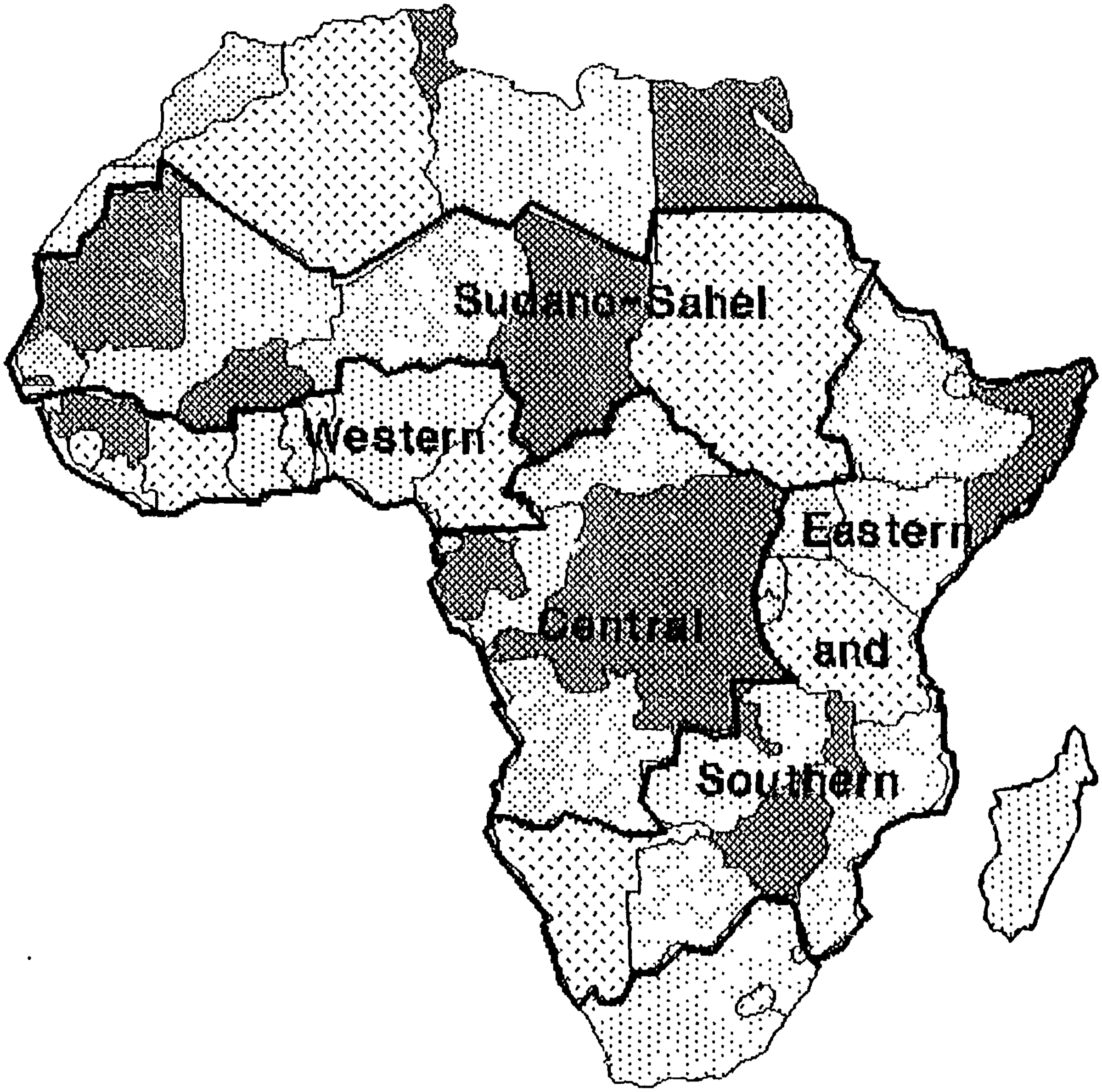
b Irrigated land as a percentage of arable and permanent crop land, agricultural labour (units per arable land) and number of tractors per arable land, Fertilizer consumption in terms of kilogram of plant nutrients (NPK) per hectare of arable and permanent crop land

Source. **Data are taken from the State of Agriculture and Food (FAO),1990.**

The Food and Agriculture Organization (FAO 1986) has classified tropical African countries into five agro-climatic zones. They are Semi-Arid Sudano-Sahel, Humid and Sub-humid Western Africa, Humid Central Africa, Sub-humid and Mountain Eastern Africa and Sub-humid Southern Africa. Following La-Anyane (1985), countries in sub-humid Eastern Africa and sub-humid Southern Africa regions are grouped together to form the Sub-humid Eastern and Southern Africa region. Thus, four main agro-climatic regions will be discussed in this study (see Map 1)

Agricultural input use varies across the four agro-climatic regions as shown in Table 2.0. Although tropical Africa can be characterized as land-surplus relative to the Asian countries, the distribution of arable land is uneven across the main agro-climatic regions. The cultivable land is 306 million hectares (mill. ha) in Eastern and Southern Africa, 286 mill.ha in Central Africa, 123.9 mill. ha. in Sudano-Sahel and 96 mill. ha in Western Africa region. Humid Central Africa has the highest land reserves, and only about 18 percent of the arable land is cultivated while the other three regions use from 47 to 57 percent of the arable land. Most of the land reserves are marginal land which can produce only half of the yields of the very suitable areas (Harrison,1989). Harrison has also pointed out that the Sahel and the Western Africa region are already cultivating over 90 percent of their most productive agricultural lands.

Soil type and quality are critical factors influencing African agriculture. The importance of these factors in terms of agricultural production shows also a wide variation among the main agricultural regions in tropical Africa. Soil type ranges from calcarious desert soil in the semi-arid region, to a deeply weathered and acid soil of the



Map 1: Four Agro-climatic Regions in Tropical Africa

humid Central and Western African regions (FAO,1986). The soil type in the Semi-arid Sudano-Sahel region is dominated by porous loamy sands that have lower fertility and water-holding capacity. The variability of rainfall and poor soil fertility tend to be the most constraining factors in the semi-arid region (Malton,1990). On the other hand, the dark alluvial soils in humid Central and Western Africa have greater water availability but the soil layers are thin and susceptible to degradation when the protective cover of vegetation is removed. The expansion of agriculture is also constrained by the limited solar insolation and low soil fertility (Ter Kuile,1986). The Eastern and Southern region is characterised by its high altitude which is responsible for the variation of rainfall across these countries, ranging from 1300 to 3500 mm (La-Anyane,1985)

Improving soil fertility is important to accelerate agricultural production in tropical Africa. Agricultural production is low because of low soil fertility combined with a reduced fallow period under extensive farming methods. The level of fertilizer consumption is low relative to the other developing countries (Paulino,1986). Fertilizer production in tropical Africa is estimated to be about 1 percent of world production, while fertilizer use is about 3 percent of the world figures (Bumb, 1991). The difference is filled with imports. During 1980-87 period, the average rate of fertilizer consumption in tropical Africa is estimated at about 11.3 kg. nutrients per hectare of arable land (see Table 2.0), and has been increasing at 6 percent per year since 1978-80. Among the agro-climatic regions, the Sub-humid Eastern and Southern African zone has the highest fertilizer consumption rate (13.1 kg/ha.) while the humid Central Africa zone has the lowest rate (1.9 kg/ha). The rate is 6.1 kg/ha, in the Western Africa, and 4.1 kg/ha in

Semi-arid Sudano-Sahel zone.

Tropical Africa is also one of the least mechanized regions of the world. A study by the Food and Agriculture Organization (1986) showed that only 1 percent of farm power is provided by mechanical equipment, 10 percent is provided by animal power and 89 percent by human labour. Improved farm equipment, therefore, has not found its way into African agriculture. The distribution of agricultural tractors per thousand hectares of arable land across agro-climatic regions is shown in Table 2.0. The average number of tractors for tropical Africa is 1.7 per thousand hectares in 1987. Eastern and Southern region has 3.6 tractors per thousand hectares, Western Africa has 1.6 and both the Sudano-Sahel and Central Africa regions have 0.7 tractors per thousand hectares.

In conclusion, much of African agriculture can be termed as a farming system where farmers use few purchased inputs. The farming practices are dominated by small farmers that produce food for consumption and some surplus for market. Agricultural land potential and the utilization of purchased inputs varies and hence agricultural production is different across the main agricultural regions. Any effort to assess the agricultural situation and identify the related pricing policies effects on agricultural production in tropical Africa without taking into account these agro-climatic attributes is likely to suffer from over generalization.

2.3 Agricultural Performance

Tropical Africa is currently facing an agricultural crisis, despite the continent's agricultural potential. It has experienced declining per capita food and agricultural production since the 1970s. The challenge now confronting many policy-makers is how to improve the productivity of the agricultural sector so that there is enough food for the African people and to generate the foreign earnings required for modernization.

2.3.1 **Total Agricultural Production**

In the 1970s, total agricultural production in tropical African countries grew by 1.4 percent per year while the population rose at a rate of 2.7 percent. As a result, the agricultural production per head declined by 1.5 percent per annum (see Table 2.1). Agricultural performance of the region did not improve much in the 1980s, although many African governments attempted to diversify their agricultural production bases. The growth rate of agricultural output increased to 2.8 percent per year in the 1980s. However, the agricultural production per capita still declined by 0.4 percent per annum because of the higher population rate of growth (3.2 percent) in Tropical Africa and the lack of sufficient technological innovations required to raise factor productivity.

The pattern of the agricultural growth rate in the region, as a whole, may mask the different patterns experienced by the individual countries. The annual growth rate of agricultural production for twenty tropical African countries is also shown in Table 2.1. It should be noted that only six countries registered an agricultural production growth rate of over 3 percent per year during the 1970s period and another 11 countries experienced a growth rate of between 1 and 2 percent per year. In 1980s, the agricultural performance improved in many countries. The number of countries with a growth rate greater than 3 percent has increased to eight, while another nine countries have shown an annual growth rate of between 2 and 3 percent per year. On per capita basis, however, all tropical African countries, except five countries for agricultural production and six for

Table 2. 1 Statistics of Agricultural Performance per Annum (in percent), 1970-90

	Rate of GROWTH OF TOTAL PRODUCTION				Rate of GROWTH OF PER CAPITA PRODUCTION			
	AGRIC		FOOD		AGRIC		FOOD	
	70-80	80-90	70-80	80-90	70-80	80-90	70-80	80-90
A." High Performance"[1]								
Ivory Coast	5.1	3 2	6 0	3 6	1 0	-0 7	1 9	-0 3
Tanzania	4 2	2.5	4 9	4 9	0 8	-1 2	1 5	1 5
Malawi	3 8	1.2	3 2	3 2	0 6	-2 3	-1 3	-1 3
Zambia	3 7	3 7	3 8	3 8	0 5	-0 2	-0 2	-0 2
Kenya	3 2	4.3	2 3	4 7	-0 5	0 5	-1 4	0 9
Mali	3 0	2 5	2 7	2 7	0 7	-0 2	0 4	-0 5
B. " Fair Performance"								
Zimbabwe	2 3	3.5	1 1	2 6	-0 8	0 3	-1 9	-0 5
Sudan	2.2	2.2	3 1	3 1	-1 6	-1 6	0 4	0 4
C "Low Performance"								
Chad	1.8	2 3	1 9	2 0	-0 3	-0 1	-0 1	-0 4
Zaire	1 7	2.1	1.8	2 1	-1.1	-0 9	-1 1	-1 0
Somalia	1 6	3.4	1.6	3 4	-2 2	0.0	-4 2	0 0
Ethiopia	1.6	0.5	1.6	0 6	-1 1	-2 0	1 1	-1 9
Madagascar	1 5	1.9	1.5	1 9	-1 2	-1 2	-1 2	1 2
Cameroon	1 4	1.9	1 4	2 0	-1 3	-1.3	-1 3	-1 2
Senegal	1 4	3.2	1 4	3 2	-1 4	0 3	-1 5	0 4
Burundi	1 3	2 5	1 2	2 4	-0 3	-0 4	-0 4	-0 5
Nigeria	1 0	4 8	1 0	4 8	-2 3	-1 4	-2 2	1 4
D " Very Low Performance"								
Uganda	-0.7	1 0	-0 3	1 0	-3.6	1 4	-3 2	-2 6
Ghana	-0 9	4 5	-0.9	4.7	-3 0	1 1	-3 1	1 3
Mozambique	-0 9	0.6	-0 3	0 7	-3 3	-2 0	-2 8	-1 9
Angola	-3 5	-0.2	-0 2	0 2	-6.6	-2 8	-3 0	-2 4
Tropical Africa	1.4	2 8	1.8	2.7	-1 5	-0 4	-1 2	-0 5

Note. The Countries are ranked according to the rate of growth of total agricultural production during the 1970-80 period

1 High Performance refers to the 1970-80 agricultural growth rate, over 3 percent per annum, Fair Performance include the rate of growth between 2 to 2 9 percent per year, Low performance refers to the growth rate between 1 to 1 9 and Very Low Performance is growth rate below 1 percent per year

Source The data used to calculate the annual growth rate are taken from UNCTD, Handbook of International Trade and Development Statistics,1991 table 6 5 p 467 food production showed negative growth rate during the 1980s.

2.3.2 Agricultural Food Production

Food production has lagged behind food demand in many African countries. Per capita food production declined by 1.2 percent, although total food production in Tropical Africa rose by about 1.8 percent per year during the 1970s (see Table 2.1). The average growth rate in per capita food production continued to deteriorate in the 1980s, indicating a fall of 0.5 percent per annum, even though there was some improvement in food production of 10 percent in 1985, followed by a further increase of 4 percent in 1986.

Food production in Africa constitutes a large portion of overall agricultural production. Because of this, a close relationship exits between total agricultural growth and food production growth rates. Countries with a high growth rate in total agricultural production in the 1970s, also showed a high growth rate of food production. Four countries (Ivory Coast, Tanzania, Malawi and Zambia) registered an annual growth rate of food production of more than 3 percent in the 1970s. Thirteen countries registered a growth between 1.0 and 2.7 percent per year. Another four countries showed a negative trend in food production over the same period. The per capita growth rate in food production was positive in only four countries in this sample during the 1970s, while seventeen out of twenty-one countries showed a declining growth rate. The number of countries with a positive trend in per capita food production increased in 1980s to six countries while fourteen countries showed a negative growth rate in per head food production.

2.3.3 Agricultural Export Production

The export volumes of most the countries in the region experienced positive (about 2.3 percent per year) growth rates during the 1960s (Alexandratos, 1988). Since then, the growth rate of the exports declined by 2.2 percent per year in the 1970s as shown in Table 2.2. In the latter period, 25 countries experienced a deteriorating agricultural export performance. Agricultural exports further declined at an average rate of 0.4 percent per annum from 1980 to 1985. Only seven countries (Burkina Faso, Cameroon, Kenya, Malawi, Mali, Mauritius and Ivory Coast) have maintained a positive annual growth rate in agricultural exports during the 1961-85 period (Alexandratos, 1988) These countries include those with high agricultural output, indicating that there exists a relationship between the performance of total agricultural production and exports. The positive relationship between overall agricultural production and exports may imply that countries with higher total agricultural output export more to foreign markets and proceeds of the increased exports may bring in more of the scarce capital inputs needed to further raise food production.

Africa's share in the world production for primary agricultural commodities declined since the 1970s. Most of the African countries depend for thier export earnings on few (one or two) primary commodities which have little domestic demand The combination of higher concentration of export crops and limited possibility for domestic absorption of export products, has made the countries vulnerable to vagaries in the international market.

Table 2 2 Growth Rates and Share of the Agricultural Exports in Tropical Africa[1]

Country	Growth Rate of Exports		Share in total Exports (%)	Country	Growth Rate of Exports		Share in Total Exports (%)
	70-80	80-85	80-85		70-80	80-85	80-85
Rwanda	9.0	7.3	82	Mauritania	-1.8	-3.0	12
Malawi	7.3	1 9	92	Sudan	-3.0	-4.1	19
Mali	6.3	0.2	95	Madagascar	-3.6	-2.8	82
Swaziland	4.7	2.5	52	Ethiopia	-4 2	-3.1	81
Botswana	4 5	6.1	10	Tanzania	-4.4	-4.9	38
Zimbabwe	3 8	2.6	41	Zambia	-5 5	7.6	41
Kenya	3.6	4.0	86	Togo	-5.6	0.2	38
Ivory Coast	3.6	4.7	70	Ghana	-6.5	-5.2	28
Chad	2.2	-2.8	20	Nigeria	-6.8	-5.7	3 0
Burkina Faso	1.7	0.6	89	Mozambique	-7.9	-24.4	49
Cameroon	0.5	0.1	45	Guinea	-8.3	-14.6	6.0
Zaire	0 3	-5.1	16	Uganda	-8.4	5.5	91
Liberia	-0.1	1.2	28	Benin	-12.4	21.8	77
Burundi	-0.2	9.2	90	Congo	-15.4	15.8	17
Sierra Leone	-0.3	5.1	35				
Gabon	-0 6	-14.2	2.0				
Gambia	-1 2	0.8	52				
Somalia	-1.3	-11 7	36				
Senegal	-1.8	18	24				
				Tropical Africa	-2.2	0.4	26

1. Agricultural exports are in physical units.

Source: Alexandratos (1988) World Agriculture Toward 2000, pp.323

The shares of tropical Africa's total exports (agricultural and non-agricultural) relative to world trade and to Less Developed Countries (LDC's) from 1960 to 1990 are shown in Table 2 3. The share of tropical Africa in total world trade in the early 1960's was 2.9 percent. Since then, there has been a gradual decline and in 1990 the share was down to 1.1 percent. Africa's export share relative to other LDCs increased in the 1970s, but it subsequently deteriorated in the 1980s, and was down to 5 percent of LDC exports in 1990.

In summary, per capita food and total agricultural production deteriorated in the 1970s and 1980s Hence, many countries became dependent on food imports Moreover, there was a stagnation in agricultural exports and loss of the export share in world trade. As a result, many countries had difficulty in importing the necessary agricultural inputs such as fertilizer.

Table 2.3 Total Export Value: The world, Less Developed Countries (LDCs) and Tropical Africa

Region	1960	1970	1980	1990
	Billion of current US dollars			
World	129.1	315.1	2002	3415.3
LDCs	28.3	57.9	573.5	738.0
Tropical Africa	3.8	8.0	49.4	36.8
Share of Tropical Africa (of)		(percent)		
World exports	2.9	2.5	2.5	1.1
LDC exports	13.4	13.8	8.6	5.0

Source: UNCTAD, Handbook of International Trade and Development Statistics (1991), Table 1.1, pp.4-6.

2.4 Causes of Agricultural Problems

Several hypotheses have been put forward to explain the causes and establish potential remedies for the poor agricultural performance in tropical Africa. In general, the debate on African agriculture is based on two main schools of thought which appear largely opposed to one another: underdevelopment theory and development theory. According to the proponents of underdevelopment theory, the agrarian crisis in tropical Africa is mainly the outcome of a world economy designed to serve the interests of the industrialized nations. Therefore, restricting the region's openness to external economies through an import substitution strategy will minimize or even correct the excessive vulnerability of the African economy (Timerlake,1985). On the other hand, the price fundamentalist (or advocates of the development theory) have underlined the increasing imbalance between population and food supply (Lofchie,1989) . The roots of the agricultural problems, as they see it, include high levels of population, low levels of technology and government policies that favour urban areas at the expense of agriculture.

The fact that these two groups used different models based on different assumptions and reach different conclusions is quite evident. The proponents of underdevelopment theory emphasize the factors that are external to a specific country as well as to the region, such as Africa's dependence on few primary commodities and their declining terms of trade, lower demand for agricultural commodities and the ever-increasing producer support policies employed by the industrialized countries. In contrast to the above line of reasoning, the supporters of the traditional development theory emphasize the internal factors. Agricultural pricing policies, marketing intervention and higher population growth were the key to the arguments (Lofchie,1989). Privatization for publicly-owned enterprises, trade liberalization, and family planning were seen not only as means to reverse the agrarian crisis, but also to improve the whole economy In discussing the gap between these two approaches, Timerlake (1985,p.83) noted:

> Those to the left see cash crops as naked capitalism, continuing to exploit independent Africa as it did the colonial Africa severely exploiting the majority of peasants. Those to the right see cash crops as the only way Africa can enter the world marketplace and earn the foreign exchange which so desperately needs to improve the (welfare)...of it's people.

Although both approaches offer insights on the current agrarian crisis, there is now some consensus among African observers that the continent-wide tendency to control and depress agricultural prices played an important role in contributing to the agricultural crisis (Ghai et al.1987). The weight needed to assign to the price effect in explaining the agricultural problem is still a much debated question.

2.5 Government Intervention in Agricultural Markets

Agricultural pricing policy is one of the key farm issues now facing many tropical African countries. African governments have pursued pricing policies that regulated food prices, taxed agricultural export commodities and overvalued domestic currency (World Bank,1981). The main economic rationale for the pricing policies related to the vulnerability of agricultural producer prices to climatical variability and price uncertainty Governments have intervened in agricultural markets to reduce price and production instability, hence creating a more favourable environment for agricultural production. As a consequence, governments have established marketing boards which were responsible for the day-to-day marketing operations of agricultural products (Jones, 1984). The main objectives of marketing boards have included: ensuring national food security, and generating revenues needed for the creation of national research and extension services, and road infrastructure (Ghai et al.,1987, Hanrahan et al.1981).

The marketing boards have administratively set the price of major staple foods and export commodities and enforced the official producer price through buying and selling operations of marketing boards (Hanrahan et al. 1981).

The policy instruments have affected the level and composition of agricultural production, thereby transferring resources either from agriculture and/or within the sector. Development economists have spent a great deal of efforts in examining the effect of government intervention on producer price incentives and production of export and food crops. A World Bank (1981) report (Berg report) reviewed government interventions in agriculture and the effect of these interventions on producer price incentives in Africa during 1970s. The report showed that governments used pricing policies and inward-looking trade strategies that represent a systematic bias against the agricultural sector. The report concluded that pricing policies pursued by the governments in the region have (i) systematically taxed export agriculture by paying farmers a small fraction of world prices; (ii) and set food crop prices below the "free market" price level in order to subsidize consumer prices.

Other researchers have questioned the general conclusions made by the Berg report about export and food crop prices. Ghai and Smith (1987) used the official national producer prices for the major export and food crops in a sample of 18 tropical African countries to examine the secular movement of food and export price performance during

1970s. Their results showed that food prices rose relative to the consumer price index in most of the countries while the real producer price of export commodities declined over time. Other studies on price performance over time have also obtained similar results. One such study (Lele,1989) examined, among other things, the secular movement of food and export prices for six African countries over the 1970-87 This study also showed that the price system has favoured food relative to export crops during 1970s and mid 1980s.

The higher cost of marketing operations and failure of government policies to achieve their intended goals has recently induced many African governments to reform agricultural markets and to use pricing policies that rely on market forces (Gray,1992). The policy measures used have included the reduction of taxes on export commodities, removal of input subsidies and liberalization of the currency exchange market. Moreover, many countries in the region have liberalized food markets. Preliminary analysis on the effects of the policy reforms in agriculture suggested that the countries with stronger policy packages experienced a better exports and overall economic performance than those with weak policy reforms (Cleaver,1993, Jaeger,1992).

Despite considerable effort on producer price analysis during 1970s, our knowledge of the link between government interventions in agricultural markets and their effect on producer price incentives is still inconclusive. Moreover, most empirical studies have dealt with a limited number of tradable commodities and have mainly ignored the behaviour of food crop prices in Africa. Hence, in this study, the price performance of staple food as well as export crops, in terms of the growth rates over the past two decades for tropical African countries, is analyzed and presented in chapter six.

CHAPTER 3

LITERATURE REVIEW

3.0 Introduction

The main objective of this chapter is to discuss the methods used in assessing the effects of government intervention on producer price incentives (section 1) and to review the literature on studies of the supply response (section 2).

3.1 Calculation of Producer Price Trend

Producer prices play a critical role in the pricing policy and marketing operations of agricultural commodities. Prices received and prices paid by producers are subjected to a wide array of government intervention in all countries in the region (Hanrahan et al. 1981). For given technology and input prices, real producer prices for agricultural output can be used as a measure of producer incentives. The marketing boards, as instrument of food security, have adjusted the official producer prices to subsidize the urban consumers (Jones, 1984).

A key policy issue relating to price performance is to examine and determine the change in direction and magnitude of agricultural prices over time. In a recent study, Ghai and Smith (1987) used an exponential compound growth model to assess the change in food and export crop prices over time in selected tropical African countries. The model uses the whole sample period to estimate the annual growth rate and provides a measure of statistical significance of the estimated growth rate.

The average annual compound growth rate of producer price (nominal producer prices deflated by consumer price index) can be estimated by using the least squares method. This regression model can be represented as:

$$\ln P_t = a + b\,T + \epsilon_t \qquad (3.1)$$

Where P_t is the real price at time t, T is time trend variable, a and b parameters to be estimated in the regression. The value of the time trend coefficient represents the estimated compound annual growth rate of the price series being examined[2]

In principle, the growth rate of a real producer price may exhibit a positive trend if the marketing boards pursue pricing and marketing policies that favour farmers relative to urban consumers. On the other hand, if government pricing policy discourages agricultural producers through high taxation, the rate of change in real producer prices over time may show a negative trend. If authorities implement pricing policies that do not represent a bias against agriculture, real prices may remain constant.

3.1.1 Nominal Protection Coefficients

Producer price performance of tradeable commodities can be also assessed using a price setting criteria based on the border price as reference point that would prevail in the absence of interventions. The free on board (f.o.b) price of a export commodity is derived from the appropriate world market price. This market price is converted into domestic currency equivalent using the official exchange rate to give the border price, which is adjusted for internal transportation and marketing margins. The rationale for

---

[2] The exponential growth model assumes that the annual growth rate of price series is constant over the whole sample period. The estimated coefficient of the time trend variable is still unbiased and consistent if the price series is stationary over the sample period. The estimated coefficient can be used to approximate the annual compound growth rate of the price series, especially when the goodness of fit or the level of significance is high.

using a border price of a exportable commodity for policy analysis is based on the assumption that world price signals the producer's opportunity cost of resources and earnings from the sale of agricultural products in world markets. Aligning, therefore, domestic producer price of a tradeable commodity with its border price relates to economic efficiency of the resources and indicates an optimal situation (Lets and Scandizzo 1980).

Empirical studies on the measurement of price distortion and agricultural protection have employed a wide range of methods (Lutz et al. 1980). A simple method commonly used in estimating the effect of price policy intervention is Nominal Protection Coefficient (NPC)[3]. Although other methods give more details of the impact of the interventions than the NPC, similar conclusions can be drawn from their results (Taylor et al. 1991). The NPC is measured as the ratio of domestic price to border prices which can be represented as :

$$NPC = P_i^d / P_i^w \qquad (3.2)$$

Where P_i^d is the domestic farm-gate producer price of a commodity i for a given country and P_i^w is the border price of the commodity i expressed in country's local currency at the official exchange rate. The NPC value measures the extent of price distortion or subsidization for a given commodity arising from government's direct intervention on agricultural markets. Movements of the price ratio over time demonstrate whether official

[3] Other approaches can be used in price analysis studies. Some of these methods include the effective nominal protection, consumer subsidy and producer subsidy equivalent and resource ratio.

producer price is moving toward or away from border price or "equilibrium price". The movement of the NPC can be influenced by a change in the domestic producer, world price and exchange rates (Jaeger and Humphrey, 1988)[4]

The value of nominal protection may not necessarily be a reasonable approximation for the price distortion faced by the producers of a commodity. The degree to which a lower nominal protection coefficient impiies a bias against agricultural producer, depends on the ultimate goal of the funds extracted from taxation Governments in the region have intervened in the agricultural export market by paying lower prices relative to world prices when commodity markets are booming. A range of the NPC values rather than a single value might be more relevant in indicating price distortions. In a recent study, Bayerlee and Sain (1987) suggested that NPC values ranging between 0.85 and 1.15 reflect a policy environment free of taxation and free of subsidization The NPC value less than 0.85 implies a tax on producers of the commodity while a NPC values greater than 1.15 reflect a subsidization.

Aggregated producer prices for the main food and export crops are also important for examining agricultural production decisions in tropical Africa. A method of aggregation is, however, required in order to establish a producer price index. Different formulas are used in constructing weighted aggregate price indices The choice of a method depends on the objective of the price indices and the availability of data In any

4 The effects of agricultural policies might be decomposed into direct effects (those arising from instruments directly targeted at the agricultural sector) and indirect effects (those resulting from macroeconomic instruments such as trade measures and exchange policy. This study focuses primarily on the effects from direct agricultural policies Other studies have considered the indirect effects of macroeconomic phenomenon on the African agriculture (see Jaeger and Humphrey, 1988)

approach, it is essential to determine the base year and weights for the index. A representative base year is usually chosen for its relative stability compared to other years. In practice, it is hard to obtain any normal and stable year. The Food and Agriculture Organization (FAO) constructs agricultural statistics using 1980/81 crop as the base year. This study will employ the same base year as that of the FAO. The indices for the weighted real producer prices reflect the percentage change in the price of the commodity in a given period of time to the price paid for the commodity at a specific period of time.

Previous studies have used various weights in computing weighted producer price indices. Park (1978) argued that weights should reflect on the relative importance of each commodity and he used income shares as weights. Dormerger (1987) used both income shares and a simple average of the number of commodities used in the analysis (ie, 1/n, where n is number of commodities) as weights to examine the effect of price variability and inflation on U.S industry. Dormberger argued that his findings were unaffected by the choice of the weights. In a recent study, Jaeger(1992) used production value as weights in constructing producer price indices for a sample of African countries. In this study, a Laspeyres index was used in order to construct a weighted average of producer price for food and export crops over the 1975-90 period[5]. The production for each crop covered in the study is used as weights for the price index.

Laspeyres Price Index (L_t) = $\Sigma_{i=1} (P_{ti} Q_{ti} / P_{bi} Q_{bi})$, where P_{ti} and Q_{ti} are price and output of commodity i at time t and P_{bi} and Q_{bi} are price and quantity of the ith commodity in the base period (1980/81 = 100). In this study, the laspeyres index is chosen over the others such as the Divisa index for the availability of the data and the ease of calculation.

3.2 Literature Review of Supply Response

This section reviews the key determinants, estimation methods used and previous empirical evidence of the supply response to price and non-price factors in tropical Africa. It is divided into three sub-sections. The first sub-section provides a discussion on the main factors that influence agricultural supply. The second sub-section discusses the theoretical background for the dynamic supply response analysis. Finally, sub-section three surveys the empirical evidence on agricultural supply response in tropical Africa.

3.2.1 Price and Non-Price Incentives

Traditional production theory assumes that relative prices, technical innovation and agro-climatic situations influence the profitability and the supply of the agricultural products. Given a production technology, the relative movement in prices that farmers receive for what they produce and for what they pay for inputs and consumer goods, are critical in influencing agricultural production. Government's price policy affects producer price incentives and production in many ways. Policy measures that provide a favourable price incentive to agriculture relative to non-agriculture increases agricultural output. On the other hand, policy measures that lower agricultural price incentives through heavy taxation (direct or indirect) may depress producer incentives leading to a reduction in farm profitability and agricultural production (Schultz, 1978).

Adoption of appropriate technology in the agricultural sector can also raise the productivity of farmer's resources under a given price structure. Government investment in the non-price factors can also improve net farm revenue by increasing agricultural output and/or lowering costs of production. The availability of a better roads and transportation facilities can reduce, for instance, the cost of production by lowering transportation costs. Effective extension services for farmers can assist producers to respond to economic stimuli by reducing the cost of market information. Policy measures that encourage the adoption of high-yield cultivars, fertilizer usage and the better agronomic farming practices can also increase agricultural production and improve the profitability of agriculture.

Weather conditions help to determine agricultural potential and constraints in a region. Bad weather condition such as a drought, can adversely affect farm profitability by reducing agricultural production. Farmers in poor agro-climatic regions (semi-arid Sahel zone, for example) may lack the physical resources to cope with yield fluctuation. Investment in irrigation can play an important role in stabilizing agricultural production.

3.2.2 Agricultural Supply Function

Econometric studies on supply analysis are carried out within the microeconomic framework, applying the results that hold for a firm directly to an industry and country. In this framework, the production function forms the foundation of agricultural supply analysis (Heady, 1957). The static supply function, derived from the static theory of optimization, provides the conceptual starting point of the analysis of the producer supply response (Heady, 1957). The supply function of a commodity refers to the quantity offered for sale at various prices, other factors remaining constant.

The estimation of the agricultural supply response to price is complicated since agricultural production decisions are subjected to a great deal of uncertainty, resulting from variability of agricultural output, yield and prices. Moreover, a production function is time dated and output measured over time tends to be in disequilibrium. Farmers require time to adjust to the changes in the relevant variables such as prices and technology. These problems have motivated researchers to frame supply models that accommodate the dynamic process that is inherent in production.

3.2.3 Nerlove Supply Response

It is widely recognized that producer's behaviour should be formulated on a dynamic basis (Nerlove, 1958). In dynamic modelling, two econometric approaches are proposed: indirect estimation and the direct approach.

The indirect approach assumes that the supply response to output price can be derived from a knowledge of the input demand response to prices (Griliches 1957). The aggregate supply elasticity is calculated by summing the products of the elasticity of supply with respect to each input, and the elasticity of input with respect to it's price. The indirect estimation approach requires a reliable data on the quantities and prices of the main inputs, which are not currently available in most of the African countries.

A model that has a wide acceptance in agricultural supply analysis is the direct estimation method, formulated by Nerlove (1958). The Nerlove model is composed of three equations (Askari and Cummings (1977).

$$Q^*_t = a + b\, P^*_t + U_t \tag{3.3}$$

$$Q_t = \pi\, Q^*_t + (1-\pi)\, Q_{t-1} \qquad 0 < \pi < 1 \tag{3.4}$$

$$P^*_t = P_{t-1} + \beta(P_{t-1} - P^*_{t-1}) \qquad 0 < \beta < 1 \tag{3.5}$$

Q^*_t is the desired level of output in period t, Q_t is the actual output level in period t, P_t^* is the expected real producer in period t, P_{t-1} is the actual real producer price in period t-1 and P_t is the actual real producer price in period t. The coefficients of the behaviourial equations are a and b. The expectation coefficient is β and the rate of adjustment associated with technical and institutional rigidity is π (Nerlove, 1958). U_t is a disturbance term.

The conceptual starting point of the statistical derivation of a supply function is equation (3.3) which expresses the planned (or desired) output as function of expected output price. The formation of future expectations on the price and output are essential for the stability of the equilibrium. It is, however, a difficult task to know exactly how farmers form their price expectations, because both the planned output and expected price are subjective matters which are not observable. Weather and other climatic variables can make realized output deviate from planned output. In addition, only past and to some extent current price data are available to farmers. Hence, proxies for expected prices and output need to be used to estimate output response to price. Nerlove (1958) postulated two types of models: an adaptive expectation model, and a partial or stock adjustment model.

Equation (3.5) represents Nerlove's adaptive price expectation approach. It states that farmer's price expectations are derived from the sum of the past actual price observation and a proportion (ß) of the difference between actual past price and past expected price. The weight assigned to these past prices are arranged in such way that the recent price observation receives the maximum weight and the distant past price receives minimum weights. Equation (3.4) is the partial adjustment hypothesis. It describes the rule for the actual output level as function of actual and planned output in the previous period. It states that the actual output is partially adjusted in proportion to difference between last period's actual output and long-run equilibrium output. Assuming that the producer's price expectation is adaptive and the planned output is partially adjusted, the following reduced- form equation can be derived by combining the above three equations. As shown by Hallam (1990,p51), this yields,

$$Q_t = a\pi\beta + b\pi\beta\ P_{t-1} + [(1-\beta) + (1-\pi)]Q_{t-1} - (1-\pi)(1-\beta)\ Q_{t-2} + V_t$$

where $V_t = U_t - (1-\beta)\ U_{t-1}$ (3.6)

The problem of this estimation equation is that π and β cannot be identified separately. The estimating equation can be solved under the assumption that either of the two coefficients is equal to 1. This restriction implies that there are either no delays in adjustment or farmers use a naive price expectation formation process.

3.2.3.1. **Adaptive expectations model**

The basic premise of the adaptive expectations model is the assumption that producers form long-run expected prices for their produce based on the past observed prices. The general formulation of this model consists of a supply function that postulates the actual output (Q_t) as a function of the expected producer prices (P^*_t), that is,

$$Q_t = a + b\ P^*_t + U_t \qquad (3.7)$$

and mechanism for forming price expectations (equation 3.5).

The reduced-form supply equation based on the adaptive hypothesis can be obtained by inserting the adaptive expectation hypothesis (equation 3.5) in equation (3.7). After applying the Koyck's transformation to the resulting equation[6], we get

$$Q_t = a\beta + b\beta\ P_{t-1} + (1-\beta)\ Q_{t-1} + V_t \qquad (3.8)$$

---

[6] The adaptive expectation hypothesis (equation 3.5) can also be written as
$P^*_t = (1-\beta)\ P^*_{t-1} + \beta\ P_{t-1}$ (i).
Inserting equation (i) into equation (3.7), results
$Q_t = a + b(1-\beta)\ P^*_{t-1} + b\beta\ P_{t-1} + U_t$ (ii).
Then by lagging equation (3.7) and multiplying through by (1-ß), gives
$(1-\beta)\ Q_{t-1} = a(1-\beta) + b(1-\beta)\ P^*_{t-1} + (1-\beta)\ U_{t-1}$ (iii).
Subtracting equation (iii) from equation (ii), yields the reduced form equation
$Q_t = a\beta + b\beta\ P_{t-1} + (1-\beta)\ Q_{t-1} + U_{t-1}$.

This equation states that the actual output of a crop is a function of the lagged output price, lagged dependent variable and an error term.

3.2.3.2. **Partial Adjustment Model**

Another expectation hypothesis is partial output adjustment hypothesis which is a long-run output concept. It assumes that producers base their long term output plans on the price for the preceding harvest period. that is;

$$Q^*_t = a + b\,P_{t-1} + U_t \qquad (3.9)$$

Producers are unable to adjust actual output instantaneously to changes in output prices because of capital, institutional and cost constraints. The actual output is partially adjusted in proportion to difference between last period's actual output and long-run equilibrium output (equation 3.4). The supply function based on the partial adjustment hypothesis can be derived by replacing the optimal output (Q^*_t) in equation (3.9) with Q^*_t in equation (3.4). This yields

$$Q_t = \pi a + \pi b\,P_{t-1} + (1-\pi)\,Q_{t-1} + \pi\,U_t \qquad (3.10)$$

Thus the actual output is a function of producer price at time t-1, lagged dependent variable and disturbance term. The output is therefore partially adjusted in proportion (π) to a difference between last period's actual output and long-run equilibrium output.

It is well known that the adaptive expectation and partial adjustment models have similar reduced forms. The two models differ, however, in their conceptual basis and the error structure. The adaptive expectation model is based on uncertainty about the future evolution of prices, whereas the stock adjustment model is due to technical, institutional rigidity, inertia and cost of change (Greene, 1990). Moreover, the disturbance term of the adjustment model (πU_t) is the error term in the structural equation multiped by a constant parameter. The error terms of the adaptive expectation model follow a moving average process (i.e, $V_t = U_t + (1-\beta) U_{t-1}$). As a result, estimating an adaptive expectation model with ordinary least squares may lead a biased and inconsistent parameter estimates, since the values of lagged dependent variable are likely to be correlated with the error term But, if least squares is used on the partial adjustment model, the estimated coefficients will be consistent and efficient as number of the observations in the sample approach infinity (Greene, 1990).

3.3 Evidence of Individual Crop Supply Response

Empirical assessment of agricultural supply response to price and non-price factors is often complicated by the fact that, in any economy, there is an array of prices. And change in any price can lead, in principle, to a change in agricultural production. Hence, producer response can vary depending upon which relative price has changed. Three types of supply response to output prices are identified in the supply studies. (i) There is the supply response of aggregate agricultural output to the domestic terms of trade. (ii) There is individual crop response to changes in crop output prices. The individual supply response to price is likely to be larger than the aggregate supply response since farmers can allocate resource such as land and labour more easily between individual crops than they can devote additional resource to the whole sector. (iii) there is supply response of the marketed surplus (the residual after farmer consumption is considered) to changes in the relative price

Individual crop supply response studies have dominated most of the supply response literature dealing with tropical Africa. Most of the econometric crop response studies have used a variant of the Nerlovian functional form. The variations relate to the crops under investigation (annual versus perennial), the inclusion of non-price factors that influence crop production such as weather, infrastructure, and technological changes, and the time horizon considered for each crop (Bond, 1983).

In analyzing the farmer's output response to prices and other factors, an explicit distinction between the types of crops studied should also be made. It is noteworthy that annual crop output can be changed, in the short run, by altering either the acreage under farming, the intensity of cultivation or both. In this case, the desired output is equivalent to the last period's actual output, that is, $Q^*_t = Q_{t-1}$ and the expected price at period t is equal to price level in the preceding season $P^*_t = P_{t-1}$. For perennial crops, the above model assumes that plant stocks are a fixed factor so that, in the short-run, output can be changed only by increasing the intensity of farming and improving the yield and quality of the output (Maitha, 1970). But in the long-run, crop production can be increased by raising the area under cultivation as well as it's yield. Acreage and output tend to be less correlated in perennial crops, because of the lengthy gestation period between planting and maturing stages. Generally, the acreage response to price is less than the output response to price.

Supply response studies on individual crops have used acreage as proxy for planned output because acreage is expected to be more under farmer's control than output (Bond; 1983; Rao, 1988) The problem is that the data on acreage are not readily available. Researchers have used output instead of acreage as dependent variable since the output response takes acreage and yield response into account. Bateman's (1965) studies on cocoa production in Ghana employed actual output as the dependent variable. Maitha (1970) indicated that coffee producers in Kenya responded to price incentives by adopting better agronomic practices and hence improving quality and raising the quantity of the coffee production.

On the price side, various prices have been proposed as measures of incentives. The alternative price measures used include prices received relative to prices paid, price of one output relative to other output prices. The choice of the price measures is dictated by the availability of reliable price data.

The use of the Nerlovian price expectations has dominated supply response studies. Most researchers have assumed that farmers form their price expectations on the basis of their knowledge of past and current prices (Nerlove, 1958). Bateman (1965) used the real producer price (cocoa price deflated by CPI) based on adaptive expectations hypothesis to estimate cocoa output in Ghana. Other measures have been proposed to represent expected prices. Maitha (1970) used lagged producer prices of coffee in Kenya as proxy for expected prices.

The relevance of this price formation, particularly for tree crops, has been questioned by a number of researchers. Bapna's (1980) work on supply response of crops in India examined the effect of different price expectations on supply functions. Bapna's analysis showed that aggregate price elasticity estimates vary with the price expectation mechanism. In a recent study, Tishibaka (1987) used a three year weighted average for producer price to estimate the output response for various crops in Zaire. He suggested that a weighted average of producer prices is more appropriate for perennial crops while the producer price prevailing during last cropping season can be used for annual crops such as maize and rice.

Empirical evidence on individual crop output response in the Tropical Africa suggests that African farmers are responsive to price (Bond,1983; Sed-Elmi,1992). The empirical results from these supply studies indicate that the short-run price elasticities for the individual crops are positive and statistically significant but inelastic. Furthermore, as expected, the magnitude of the long-run own-price elasticities tend to be larger than the short-run elasticities. These elasticity estimates vary from study to study even for the same commodity because of different methodology, policy regimes, level of aggregation, and country-specific factors such as technology and economic structure and agro-climatic regions (Sed-Elmi,1992; Bond,1983).

3.4 Aggregate Agricultural Supply Response

The individual crop supply response to price is crucial for optimal resource use within the sector, but this response has little relevance to the aggregate supply response to price. Aggregate agricultural production can be increased if more resources are allocated to agriculture and/or an appropriate technical innovation is introduced. An estimate of the aggregate supply response to changes in price and non-price factors is important to understand the effects of policies on agricultural growth. There are few studies of the aggregate supply response in Africa and other developing countries, and also the results of these studies lead to conflicting policy implications.

Some studies have found an aggregate price elasticity estimate that is above unity, suggesting that farmers in developing countries are highly responsive to the internal terms of trade and hence high taxation on the agricultural sector discourages producers and reduces agricultural production substantially (Peterson, 1980; Schultz,1978). Others obtained aggregate price elasticities that are inelastic (Krishna, 1982; Chhibber,1988). These authors argued that agricultural transformation is the outcome of a combination of price incentives and public investment in irrigation, research, technology adoption and reforms in the institutional structure.

Econometric studies on aggregate supply response to price can be classified into three categories: time series estimates, cross-sectional estimates, and pooled data cross-section and time series estimates. In the following section, aggregate supply response studies will be reviewed.

The direct estimation of long-run aggregate supply elasticities using time series data encounters difficulties in constructing production and price indices. Notwithstanding this problem, few time series estimates are available for African states. In a recent study, Bond (1983) estimated an aggregate agricultural supply function based on the partial adjustment hypothesis using time series data for nine tropical African countries over the period 1963-81. The study regressed agricultural output per caput on aggregate the real producer price index, a time trend variable as proxy for technical change, institutional improvement, and a dummy variable to represent the weather effect. The study found an average aggregate price elasticity estimate for the nine countries equal to 0.18 in the short-run and 0.21 in the long-run. The coefficients of the time trend were negative in seven out of ten countries studied.

Peterson (1988) believed that the price elasticity estimates from the supply function fitted to time series data underestimate the true elasticity. He argued these estimates are based on actual prices that vary more than expected prices. Peterson used a cross-country data from 53 developing and developed countries to estimate the long-run supply response to price. Agricultural output (measured as wheat equivalent) was regressed on real expected price (measured as the amount of commercial fertilizer that could be purchased with 110 kilograms of wheat equivalent), annual average precipitation, and the number of research publications (as proxy for technology). Peterson found long-run elasticity estimates ranging from 1 27 to 1.66.

This cross-country method has been criticized for overestimating the supply response to price in developing countries. Chhibbar (1988) questioned Peterson's cross-country techniques for assuming that developed and less developing countries differ only in their price structure and research publications. He argued that countries can also differ in their agro-climatic conditions, investment in infrastructure as well as in input distributions. When Chhibber included an irrigation variable into Peterson's cross-country model, the elasticity estimates declined from 1.27 to 0.97.

Supply response studies based on cross-country data are important in capturing the effects of certain type variables that may influence the agricultural variation across countries. Cross-country techniques are, however, unable to control for the correlation between un-observable productivity potential (country effects) and the explanatory variables (Binswanger et al.1987). These country effects include agro-climatic condition, water availability and potential dry matter production specific to a country. These factors are essential in explaining the country's potential in agricultural production; they do not vary over time (Binswanger et al.1987; Chhibber,1988). Estimating a supply response to price without taking these factors into account might result in a biased parameter estimates. Rao (1988) has recently reviewed agricultural supply response to price in developing countries. He argued that, in general, cross-country analysis tends to overestimate the aggregate supply elasticity whereas the time series analysis tends to underestimate the aggregate supply response to price.

Binswanger et al.(1987) combined cross-country with time series data from a sample of 58 countries using a variable intercept model to estimate cross-country aggregate supply elasticities over 1969-1978. The study found aggregate crop output elasticity (within-country estimator) with respect to output price of 0.06. The study showed that non-price variables such road infrastructure, human capital and research and extension explained most of the variation of the output supply. Other studies using pooled cross-sectional time series data have obtained a similar result on the aggregate supply response to the terms of trade. Bapna et al. (1984) estimated short-run estimates for the aggregate output in semi-arid regions in India. Their results showed an aggregate elasticity of 0.09. In a recent review on aggregate supply response to price and non-price variables, Binswanger (1989) wrote:

> The correlation between unobserved country effect and the explanatory variables can be overcome by using cross-sectional time series data and using only within- country variability. The cross- country variability can be eliminated from estimation by (1) including district or country-specific intercepts... Binswanger (1989,pp 256).

In a recent study, Jaeger (1992) used data for a sample of 21 African countries over the 1970-87 period. He estimated a cross-sectionally correlated and time-wise auto-correlated model to estimate the effects of price and non-price factors on African agriculture. Total agricultural exports were regressed on producer price for export crops, real exchange rates, a weather variable and percentage of population affected by disasters. Jaeger found that aggregate export supply response to producer prices ranged between

0.1 and 0.3. In addition, Jaeger (1992) regressed the output of staple food crops on the weighted crop export price and exchange rate. He reported positive cross-price elasticities ranging from 0.065 to 0.183. Jaeger concluded that

> Econometric analysis indicates that food production, like export, responds positively to improvements in real exchange rate. Moreover, food production correlates positively with higher producer prices for export crops, suggesting either that they are complements in production or that policies that are favourable to export agriculture also favour food producers.... Jaeger (1992, p36).

Overall the empirical evidence shows that aggregate agricultural supply response with respect to the terms of trade is in general inelastic. The implication is that, although a price incentive is necessary, it is not sufficient for the acceleration of the agricultural growth rate and the transformation of agriculture. Agricultural growth in tropical Africa has been constrained by the lack of support services such as agricultural research, infrastructure and investments in educations. Provision of these factors is also important for accelerating agricultural production in the region.

CHAPTER 4

ECONOMETRIC TECHNIQUES ON PANEL DATA

4.0 Introduction

Econometricians have combined cross-section and time series data to model complex production behaviour. They do so because, the use of pooled cross-sectional time series (also called panel) data has more benefits than separate time series or cross-sectional observations. According to Hsiao (1986) panel data give a greater number of data points on production (and more degrees of freedom) and increase the consistency of parameter estimates by controlling multicollinearity and omitted variable problems.

Panel data models differ, however, depending on the source of the variations and the assumptions regarding whether the country effect can be represented as having a fixed or a random distribution. Before estimating parameters of the explanatory variables, researchers must determine (1) the source of the variation for the individual effects and (2) whether these individual country effects can be appropriately explained by either the fixed or the random model. This chapter reviews the key approaches in modelling pooled data, and the specification tests used in choosing the most appropriate model for the data. The test results for the model specification are also provided in this chapter.

4.1 Source of Country Effects

In determining the source of variation for country effects, different models are proposed. Hsiao (1986) suggested three models that allow researchers to identify the source of output variation for an individual country effect in a pooled data model. These models include: (i) regression model with homogenous intercept and slope (pooled regression model), (ii) regression model with heterogenous intercepts but common slope (Covariance model), and (iii) regression model with the heterogenous intercepts and slopes parameters. The following section discusses the hypotheses and estimation of these models.

4.1.1 Pooled Regression Model

In a linear regression framework, the reduced-form of the dynamic partial adjustment supply model based on cross-sectional time series data can be represented by

$$Q_{it} = \alpha + \beta X_{it} + \phi Q_{i,t-1} + U_{it} \qquad 0 < |\phi| < 1 \quad (4.1)$$

Where: i= 1,...,N (countries) and t= 1,..,T (time periods). Q_{it} is export (or food) output, X_{it} encompasses the exogenous variables, $Q_{i,t-1}$ is the dependent variable lagged one period and U_{it} is a disturbance term that is independently and normally distributed over i and t with a mean of zero and a constant variance over time and across country observations. α is common intercept for the whole data set. The estimated coefficients of the lagged dependent variable (ϕ) are restricted between 0 and 1 in order to maintain the stability of the dynamic process.

The pooled regression model (equation 4.1) is based on the hypothesis that individual countries do not differ in their production behaviour. Therefore, it imposes a restriction on the structure of production across countries and over time. Applying ordinary least squares to the whole sample will provide common parameter estimates for the slopes and the intercept across countries and over time. These estimates are consistent only if the omitted country effects are un-correlated with the explanatory variables in the model (Binswanger et al.1987). Researchers have long recognized that the strong restrictions imposed by pooled regression are likely to be violated in most cases. The restricted model ignores the possibility that there exists an un-observable effect specific to a country's agricultural production function. Some of the variables excluded in production analysis include agro-climatic potential, soil quality, and management skills. The omission of these variables is likely to contaminate the estimated parameters of independent variables in agricultural supply function.

4.1.2 Covariance Model

An alternative model assumes that countries differ in their agricultural potential, and this difference is captured by allowing the intercepts in the equation to vary across the countries but to remain constant over time (so-called fixed effect). This variable intercept model can be formulated as:

$$Q_{it} = \alpha_i + \beta X_{it} + \phi Q_{i,t-1} + U_{it} \qquad 0 < |\phi| < 1 \quad (4.2)$$

Where α_i is an unobserved (fixed or random) individual effect that is specific to a country, but time-invariant and the other variables are as defined before. To estimate the parameters in the model, two techniques have been proposed. One estimation technique is to apply an ordinary least squares technique to the pooled data with N country dummy variables with no the overall intercept term in the model. An equivalent method is to use the deviations of each variable from its country specific mean over time and then apply OLS to these transformed data (Judge et al.1988). In the static regression framework, the estimated coefficients in the covariance model are unbiased and consistent (Mundlak,1978).

4.1.3 Error Component Model (Random Effect Model)

In modelling the variation of country characteristics, it is important to determine whether the country effect can be treated as a fixed or random effect. The estimated parameters of a model can vary depending on this assumption. The covariance model has been criticized for treating the country effects as fixed, given the explanatory variables in the model. An alternative model commonly applied on pooled data is the Error Component Model also called the Random Effect Model. This approach is based on the assumption that the un-observable country effects are random, like the other disturbance terms, and the effects are not correlated to the included explanatory variables (Balestra and Nerlove, 1966). This model can be written as

$$Q_{it} = \alpha + \tau_i + ß X_{it} + \phi Q_{i,t-1} + \varepsilon_{it} \qquad (4.3)$$

Where τ_i is a random variable distributed with mean $E_t(\tau | X_{it}) = 0$, variance of τ ($E_t(\tau_i^2)) = \sigma_\tau^2$, and covariance matrix $E_t(\tau_{it}\tau_{jt})$ and $E_t(\varepsilon_{it}\tau_{jt}) = 0$ for all i not equal to j. E_t is the expectation of the variables taken at time t.

The parameters in this model can be estimated using the generalized least squares (GLS) as suggested by Fuller et al.(1973). Fuller et al. showed that the GLS estimator can be represented as a weighted average of the estimates of the covariance estimator (within-country) and between-country estimators, where the weights are the shares given by the between-country variations[7]. The GLS estimator is consistent as the number of observations of the individual units or number of time series observations approach

---

[7]. The between-country estimator is obtained by applying the least squares method on the country means of all variables over time (see Judge et al. 1988; Hausman et al. 1978).

infinity (Hsiao,1986). Moreover, the generalized least squares estimator is more efficient than the variable intercept estimator if the number of individual cross-sections are large and the time series is short.

Mundlak (1978) criticized the random effect formulation for ignoring the possibility that there exists a correlation between the explanatory variables and country effects. Mundlak showed that if the explanatory variables are correlated with individual effects, then the covariance estimator is still consistent, while GLS the estimator is biased and inconsistent. This argument is important in specification tests involving random and fixed effect models.

The above models can yield inconsistent estimates if a lagged dependent variable is included in the regression equation. Balastra and Nerlove (1966) first considered a dynamic equation using panel data on the U.S gas industry. These authors suggested that applying the covariance model in a dynamic regression equation under fixed effects will yield inconsistent estimates when the number of cross section units are large and the number of time periods are short. This bias arises because the country effect is correlated with lagged endogenous variable included in the right hand side of the equation. This correlation is reduced as the number of the time periods approaches infinity Anderson and Hsiao (1982) showed that the consistency of the estimators depends upon the knowledge of the initial values of the dynamic structure and sample size In the applied panel data, researchers have often used data with a large number of cross sections covering a finite time period, thus the bias of variable intercept estimator may not disappear.

The instrumental variable approach provides consistent parameter estimates since the robustness of the estimates does not depend on the assumption of an initial value of the dynamic structure (i e the starting value of the lagged dependent variable). This method requires using an instrument that (i) is highly correlated with lagged dependent variable and (ii) is not correlated with disturbance term in the covariance specification. A number of the researchers have used different instruments in order to estimate a dynamic equation. Balastra and Nerlove (1966) used a predicted value for the dependent variable, lagged one period, as the instrument. Anderson and Hsiao (1982) proposed two instruments that provide a consistent covariance estimator. These instruments are (Q_{t-2} - Q_{t-3}) and Q_{t-2} to replace Q_{t-1}. They also indicated that the choice between the two instruments depends on the extent of the correlation between the instruments and the problem variable (Q_{t-1}). The instrument (Q_{t-2}) might be selected on the basis that fewer degrees of freedom are lost than the (Q_{t-2} - Q_{t-3}) instrument.

4.2 Specification Tests

Previous sections focused on econometric models based on different dynamic assumptions One of the methodological issues of agricultural supply studies using time series and cross-section data is to determine: (i) whether countries differ in their agricultural production behaviour, that is, whether a country effect exists in a regression equation and, (ii) if it does exist, should the country effect be treated as a fixed or random parameters drawn from a given distribution. This section discusses the specification tests that can be used to determine which econometric model appropriately represents the data. Test results on the supply response to price and non-price variables in tropical Africa using the econometric models discussed earlier are also presented.

4.2.1 Test on Variations for Country Effects

The choice of whether to estimate common coefficients for the intercept for all the countries (Pooled model) or estimate a separate intercept for each country (Within-country estimator) using least squares techniques can be made on the basis of statistical testing. A natural approach to this testing is to include the pooled model in a more general specification (Godfrey,1988). In this case, the pooled regression equation is a special case of the variable intercept model. If the pooled regression is correct, the following test statistic will be distributed as a F distribution under null hypothesis with (N+T-2,NT-N-T) degrees of freedom.

$$F = \frac{(ESS_{wn}-ESS_{p})/(N+T-2)}{(ESS_{p})/(NT-N-T)} \qquad (4.4)$$

Where T is time period, N is number of observations and ESSp and ESS_{wn} are the residual sum of squares obtained from pooled model and the variable intercept model, respectively. The null hypothesis for the specification can be formulated as

$$H_0: \alpha_1 = \ldots\ldots = \alpha_N \qquad (4.5)$$

H_a : α_i vary across countries,

where α_i is country effects (i.e intercept for ith country as stated in equation 4.2). If the null hypothesis of a common intercept for the pooled data is correct, then applying ordinary least squares (OLS) to the pooled data will yield unbiased and efficient estimates (BLUE), but OLS estimates are inconsistent and inefficient under the alternative hypothesis (Mundlak,1978).

To calculate the value of the F-test, pooled (equation 4.1) and covariance regression (equation 4.2) are applied on 20 tropical African countries over 1975-89 period for both food and export sub-sectors The results of the specification test statistics are presented in Table 4.1. The values of the F-test statistic for the export and food equations in Tropical Africa are 3.9 and 3.8, respectively[8]. The null hypothesis of the common intercept of all the countries is rejected at the significance level of 1 percent in the export as well as the food models. The result implies that the alternative hypothesis which is covariance model will give consistent parameter estimates.

The parameters of a model with heterogenous intercept and slope (price variable) are also estimated and rejected because the estimated price coefficients in most cases, were negative and insignificant due to multicollinearity resulting from large number of variables in the model[9].

4.2.2 Hausman Test

This test focuses on an econometric issue of whether country effects can be treated as a fixed or random given the explanatory variables. These assumptions were associated with different estimators. The fixed effect assumption is related to the covariance estimator while the random effect assumption is associated with the generalized least

---

[8]. The F-value for the export supply = |{(155.2-291)/33}/(291/265)| = 3.7, while that of the food supply is |{(150-284)/33}/(284/265)|=3.8. Under the hypothesis of common coefficients, the test statistic follows an F-distribution with 33 and 265 degrees of freedom. The critical value of the distribution at the 1 percent significance level is 1.70 and is 1.49 at the 5 percent level.

[9]. Hsiao (1986) suggested that a common intercept but heterogenous price effect may not be a plausible assumption because the intercept will change if the slope coefficient changes. For this reason, this model was not considered in the model specification.

Table 4 1 Summary of Specification Tests on Agricultural Supply Functions in Tropical Africa,1974-89

Category	Model Specification	F Value	Degrees of Freedom	H_0	Conclusion Retained Model is
Export	Pooled[1] Vs Covariance[2]	3 9	(33,265)	Reject[a]	Covariance
Food	Pooled Vs Covariance	3 8	(33,265)	Reject	Covariance
Export	GLS. Vs Covariance	3 0	(7,281)	Reject[b]	Covariance
Food	GLS. Vs Covariance	3 6	(7,281)	Reject	Covariance
Export	IV [3] Vs Covariance	7 8	(7,265)	Reject[c]	Covariance
Food	IV Vs Covariance	8 2	(7,265)	Reject	Covariance

Note 1 Pooled model refers to the common intercept, common slope model

2. Covariance Model refers to common slope and heterogenous intercepts

3. IV refers to instrumental variable model where $Q_{t\ 2}$ is used as an instrument for $Q_{t\ 1}$

a H_0. Common intercepts and slope for all countries The critical value for rejection at the 5 % is circa 1 49

b. H_0: No correlation between country effect and regressors variaties Critical value is 2 64 at the 5 % level

c. H_0. No correlation between country and predetermined independent variables, including the instrumental variable for the lagged dependent variable Critical value is 2 64 at the 5 % level squares estimator. Mundlak (1978) showed that the difference between these estimators can be determined by examining the extent to which the country effects are correlated with the explanatory variables. If country effects are correlated with explanatory variables, then the GLS estimator is biased and inconsistent but covariance estimators are unbiased and efficient. The correlation between the country effects and the regressors can be tested using the Hausman specification test (Hausman,1978). This test is based on the difference between the various estimators. The null hypothesis under the Hausman test states that the mean country effect satisfies an orthogonality condition, which can be specified as

$$H_0 : E_t (\alpha_i | X_{it}) = 0$$

$$H_a : E_t (\alpha_i | X_{it}) \neq 0 \qquad (4.6)$$

The Hausman test statistic is given by

$$m = (\beta_{gls} - \beta_{wn})'(V_{wn} - V_{gls})^{-1} (\beta_{gls} - \beta_{wn}) \qquad (4.7)$$

Where

α_i is the specific country effect,

X_{it} are the explanatory variables in the model.

β_{gls} is the estimated coefficient of generalized least squares under random effects.

β_{wn} is the estimated coefficient obtained under the fixed effect assumption.

V_{gls} and V_{wn} are variance-covariance estimates obtained from the GLS and within-country estimator, respectively. E_t is the expectation operator at time t period Hausman (1978) showed that in a large sample, the specification test statistic (m) is approximately distributed as CHI-Square with K degrees of freedom, where K is the number of unknown parameters to be estimated when no mis-specification is present. Hsiao (1986) suggested that using the following F-test statistic leads to a specification test equivalent to that of the Hausman test. This F-test can be written as

$$F = \frac{(ESS_{gls}-ESS_{wn})/K}{ESS_{wn}/(NT-(2k+1))} \qquad (4.8)$$

which has a central F distribution with K and NT-(2K+1) degrees of freedom. The ESS_{gls} and ESS_{wn} are the residual sum of squares of the generalized least squares (GLS) and within-country estimators, respectively. Under the null hypothesis, both the covariance estimator and GLS estimator are consistent and efficient but, under the alternative hypothesis, only the covariance estimator is consistent (Hausman, 1978 and Mundlak, 1978).

In assessing whether there is some correlation between the country effect and the regressors, Hausman test statistics are calculated for export and food supply equations based on the GLS and covariance estimators. The value of the Hausman test statistic is 3.0 for the export model and is 3.6 for the food equation in tropical Africa. Under the hypothesis of no correlation, these statistics follow a F distribution with 7 and 281 degree of freedom. The critical value for the null hypothesis at the 5 percent significance level is 2.64. Since the calculated values of the F-tests are larger than the critical value, we can reject the null hypothesis of no correlation between the country effects and independent variables in agricultural supply functions for the export and food sectors As a result, using the covariance model (or fixed effect model) to estimate agricultural supply functions yields consistent parameter estimates

The Hausman test statistic is based on the assumption that all independent variables are exogenous. This assumption may be violated if a lagged dependent variable is used as the regressor, since the lagged dependent variable is correlated with the error term. In a recent study, Arellano (1993) extended the Hausman test to incorporate the case where a lagged dependent variable is used as an explanatory variable Arellano has proposed a Hausman-type test that is valid when an instrumental variable method is applied on the transformed data in terms of the deviation of the observations from country means. This test can be written as

$$H_0 : E_t (\alpha_i | Q_{it}) = 0 \qquad (4.9)$$

$$H_a : E_t (\alpha_i | Q_{it}) \neq 0$$

Where $Q_{it} = (Q_{i,t-1}, X_{it})$.

To test further whether or not the orthogonality condition implied by the null hypothesis is violated, the parameters of the explanatory variables in supply response models for both export and food sectors are re-estimated with the instrumental variable method using the lagged dependent variable (Q_{t-2}) as instrument. The test statistics for Hausman-test type for the export regression is 7.8 and for the food equation is 8.2. Under the null hypothesis of no correlation between the country effects (α_i) and the instrument (Q_{t-2}), this test statistic is distributed as a F- distribution with 7 and 265 degree of freedom. The critical value under this distribution at the 1 percent significance level is 2.7, suggesting the rejection of the null hypothesis of no correlation between the un-observable country characteristic and instrumental variables. As a result, using the covariance model to estimate agricultural supply functions will yield consistent parameter estimates.

4.3 Conclusion

In Summary, this chapter focused on the theory and estimation of the dynamic econometric equations based on pooled cross-sectional time series data The main advantages of the pooled data models are their ability for control un-observable country effects and reduce omitted variable problems. To examine the source of variation of agricultural supply, pooled and covariance regression equations are estimated and tested using F-test statistics. The test resulted in the rejection the hypothesis of the common intercepts across countries, thereby suggesting that the inclusion of individual country intercepts in the model leads to consistent parameter estimates.

To assess further if the country effect can be modelled under fixed or random effect assumption (or whether or not the effect is correlated with the explanatory variables), the Hausman specification test was used. This test statistic allows us to compare the covariance and generalized least squares or instrumental variable estimators The results of the Hausman tests and Hausman type test support the view that there exists a correlation between country supply variation and explanatory variables. The implication of the results is that covariance estimator will give consistent parameter estimators. The correlation between explanatory variables and effect can be minimized by either using variable dummy for the intercept or through differencing out the original observations of each variable using country means over time (see Judge et al.1988). Thus, the covariance model (i.e Variable intercept) under the fixed effect assumption is retained for a detailed analysis in this study. The results of the agricultural supply response to price and non-price variables based on the covariance model will be the main focus of the sections for empirical analysis.

CHAPTER 5

EMPIRICAL MODELS

5.0 Introduction

A description of the empirical econometric model selected for the analysis of the aggregate supply response in African agriculture is presented in this chapte

5.1 Specification of Empirical Supply Model

Most of the empirical work on agricultural supply response has employed a partial adjustment supply model (Bond,1983) This study used a dynamic equation with a variable intercept to investigate aggregate crop output response for export and food crops. This model (also called the Covariance model) was selected over the other panel data models (such as the Random Component model and Instrumental Variable Model) using Hausman specification test (as discussed in chapter 4). The covariance model is based on the assumption that agricultural production differs across countries and these differences is captured by allowing the intercepts to vary across countries but remain constant over time for each country (Hsiao,1986). It was postulated that the aggregate crop output for a country is a function of real producer prices, a weather proxy, fertilizer use, a disaster proxy, a lagged dependent variable and dummy variables for the intercept. The equation for aggregate agricultural export supply was specified as:

$$QX_{it} = \alpha_i + \beta_1 (PX_{i,t-1}) + \beta_2 (WT_{it}) + \beta_3 (FR_{it}) + \beta_4 (DS_{it})$$

$$+ \beta_5 (TR) + \beta_6 (QX_{i,t-1}) + V_{it} \qquad 0 < |\beta_6| < 1 \qquad (5.1)$$

and food crop supply

$$QF_{it} = \alpha_i + \delta_1 (PF_{i,t-1}) + \delta_2 (WT_{it}) + \delta_3 (FR_{it}) + \delta_4 (DS_{it})$$

$$+ \delta_5 (TR) + \delta_6 (QF_{i,t-1}) + \Sigma_{it} \qquad 0 < |\delta_6| < 1 \qquad (5.2)$$

Where, $i = 1, \ldots N$ (country), and $t = 1, \ldots T$ (time period),

QX_{it} is an index of aggregate agricultural export output for the ith country in period t, with 1980/81 = 100. QF_{it} is an index of aggregate food crop output for the ith country in period t. PX_{it} is the ratio of a two-year average price index for the export crops deflated by current food price index with 1980/81 as base year. PF_{it} is a real food crop price index (defalted by cunsumer price index) for the ith country in time t. WT_{it} is weather variable for the ith country in time t. The deviation of the cereal yield from regression trend is used as proxy for weather variable,

TR is a time trend, FR_{it} is the quantity of fertilizer (NPK) used per hectare of arable and permanent cropland for the ith country in time t, (ton/ha),

DS_{it} is "disaster" variable for the ith country in year t. The percentage of population affected by drought, flood, war and epidemic is used to represent the disaster variable,

V_{it} and Σ_{it} are disturbance terms that are independently, identically distributed (IID) with a zero mean and constant variance; α_i is a fixed effect specific to the ith country; and ß, δ and α_i are parameters in the models that need to be estimated.

The aggregate supply equation was estimated by Least Squares on separate pooled cross-section and time series data for the export crops and food crops over the 1974-89 period. The overall intercept of the supply equation is replaced by a dummy variable for individual country intercept. This allows one to obtain individual intercepts for all N countries. To investigate the responsiveness of farmers in different agricultural regions in tropical Africa, countries were classified into four agro-climatic regions and an agricultural supply function for each agro-climatic region was estimated.

5.2 Data Sources and Measurement of Variables

The dependent variable for the supply equations was the aggregate output of the main export and food crops expressed in terms of total production rather than marketed output since the data on sales of products were limited in many countries in the region. Moreover, the use of total production is important in avoiding the speculation and inventory problems which affect sales. Weighted crop output indices were formed using Laspeyres' formula, where the weights are the output price at the base year of 1980/81. The data for individual crop outputs were taken from the Production Yearbook Statistics of the Food and Agriculture Organisation (FAO).

The producer prices used in the study were annual official producer prices prevailing at the pre-sowing period. These nominal prices were deflated by national consumer price indices to form real producer prices. Weighted producer price indices for the food and export crops were constructed using the shares of total production in the base year of (1980/81) as weights. Real food prices lagged by one year were postulated to influence production decisions. For export agriculture, a two-year average price of the export crop prices deflated by current food prices was used The data for the annual producer prices and consumer price index were taken from the African Economic and Financial Data (1989) and African Development Indicators (1992) published by the UNDP/World Bank. In general, the price data lag the production data by about three months.

The analysis of the effect of the rainfall (or moisture availability) on agricultural production requires detailed information on rainfall distribution, soil quality, and level of evapotranspiration. Yet, this information is not readily available for most of the African countries. The deviation of cereal yield from the regression trend was used as a proxy for the rainfall variable. The logic for using the proxy rests on the assumption that cereal crops are not irrigated in tropical Africa and rainfall variation is the main factor causing the deviation of cereal yield from its regression trend line (Jaeger, 1992). The data for cereal yield were taken from the Production Yearbook published by the FAO 1985 to 1991 and World Indices of Agricultural and Food Production reported by United States Department of Agriculture (USDA,1977-1986).

Fertilizer use per hectare of arable and permanent cropland was included in the regression to capture the impact of fertilizer policy on crop production. African government agencies have regulated the distribution of the fertilizer and subsidized fertilizer prices to encourage fertilizer consumption. The data of fertilizer use were taken from the United Nation, Statistical Yearbook (1982,1991) and from FAO (1985-92).

A disaster proxy was also included in the model to account for non-economic variables that can adversely influence agricultural production. These factors include droughts, civil war, epidemics and political unrest. The percentage of the population affected by the disasters was used to approximate these factors. The information on the number of the people affected by disaster was from the recently published data of the "Disaster History" reported by USAID (1992).

Chapter 6

RESULT: PRODUCER PRICE PERFORMANCE

6.0 Introduction

To examine the effects of the government intervention on producer incentives, real producer prices of the five main staple food crops (maize, rice, sorghum, millet and cassava) and seven export crops (coffee, cocoa, cotton, groundnuts, tobacco, tea and banana) are analyzed for twenty-one selected tropical African countries. All nominal producer prices are deflated by national consumer price indices to obtain real producer prices. The percentage annual compound growth rates of the real producer prices for both export and food crops were calculated using a log-linear regression equation (equation 3.1) in two selected periods; 1975-90 and 1981-90. The policy distortion of producer incentives was calculated using the Nominal Protection Coefficient (NPC) over the selected two periods. This chapter presents the main findings of price performance for food and export crops. The first section analyzes the domestic producer price performance for food and export crops. The second section provides the results of the NPC analysis for the principal crops.

6.1 Changes in Real Food Crop Prices

The results of the estimated percentage annual compound growth rates of real producer prices of the food crops are listed in Table 6.0 and summarized in Table 6.1. For each commodity, countries are ranked in order of the degree of change in real producer prices over the whole sample period.

Table 6 0 Compound Annual Growth Rates of Real Producer Prices for Main Food Crops in the Selected Tropical African Countries, 1975-90 and 1981-90

Commodity/ Country	Annual Percentage Growth Rate in Real Producer Prices 75-90	81-90	Commodity/ Country	Annual Percentage Growth Rate in Real Producer Prices 75-90	81-90
Maize			Millet		
Central A Rep [1]	8 75***	8 50***	Niger	4.68***	6.07***
Somalia[1]	5.56**	-1 75	Nigeria	3.46**	0 9
Nigeria	2 45*	10 39**	Gambia	-1 14**	-3 99*
Kenya	1 89**	1.34**	Burkina Faso.	-2.18*	-7 74***
Botswana	1 50**	0 84	Togo[1]	-2.61*	-4.43***
Congo Rep [1]	0 18	-1 12**			
Ivory Coast	0 04	15.35	Sorghum		
Zambia	-1 26	-4 22**	Central.A Rep	12 14***	13.64***
Malawi	-1 29**	-1 87	Somalia	1 98	17 42***
Tanzania	-1 89**	-1 75	Sudan[1]	0 64	1 98
Togo	-2 10	-7 04**	Senegal	-0 39	0 63
Burkina Faso	-2 16*	-7 23***	Malawi	-1.11	-0 49
Rwanda	-2 63*	3 76	Botswana	-2 47***	-1 21**
Cameroon	-2.66***	-3 67***	Rwanda	-2.51***	1 28
Ethiopia	-4 37***	1.33	Ethiopia	-3 60***	2 43
Burundi	-4 79***	-9 47***	Cameroon	-4 29***	-4 32***
Gambia	-5 12***	1.85	Tanzania	-6.05**	-5 36**
Ghana[1]	-5.50***	-9 95***			
Zaire	-20 2***	-36 3***			
Cassava					
Central A Rep	16 33***	6 33**	Rice		
Madagascar	5 15***	-3 47**	Nigeria	1.06	7 75***
Togo	1 67	-6 03***	Tanzania	0.6	0 3
Cameroon	-0 29	2 16**	Cameroon	0.38	-3 78***
Liberia	-0.46	12 10***	Senegal	-0.86*	1.13**
Congo Rep	-2 68***	-3 68***	Liberia	-1 9**	6 64***
Nigeria	-2 69*	-11 09***	Ivory Coast	-4 63***	0.53
Ghana	-3 28*	-5 63	Gambia	-4 66***	-6.53***
Malawi	-3 75***	3 19**	Zaire	-15.9***	-40 7***
Tanzania	-3 93***	-2 11			
Ivory Coast	-1 41	-3 02**			
Zaire	-16 7***	-33 3***			

1 the data span 1975-89 for these countries.

Also *, ** and *** imply the growth rate is Significant at the 10 percent, 5 percent, 1 percent level, respectively

Table 6.1 Summary of the Annual Percentage Growth Rate of the Real Producer Prices for the Main Staple Food Crops,(1975-1990)

Commodity	Positive Significant[a]	Negative Significant	Not Significant[b]	Total
		(Number of price series)		
Maize	5	10	4	19
Rice	0	5	3	8
Cassava	2	6	4	12
Sorghum	1	5	4	10
Millet	2	3	0	5
Total	10	29	15	54

a. Significant at the 10 percent and lower levels
b Not-significant refers to the positive and negative growth rates of real producer prices of the food crops that are not statistically different from zero

6.1.1 Maize Price

Maize is one of the main staple food crops in tropical Africa, particularly in Eastern and Southern Africa. The price data for maize were available in 19 countries and the annual percentage growth rate of real producer prices for maize were calculated in these countries over the selected sample period. Over the 1975-90 period, the growth rate of real producer price was statistically significant (at the 10 percent and lower levels) in 15 and insignificant in 4 cases (see Table 6.0 and 6.1). The real producer prices of maize increased significantly in five countries, namely Central African Republic (CAR 8.8), Somalia (5.6), Kenya (1.89), Botswana (1.50) and Nigeria (2.45). However, real producer prices decreased significantly in ten other countries.

An examination of the annual growth rates of real maize prices over the 1981-90 period indicates that there were three countries, namely; CAR (8.5 percent per year), Nigeria (10.4) and Kenya (1.3) that experienced a significant positive growth rate of the real maize price while eight countries exhibited a negative growth rate. The growth rates of the real maize price were statistically insignificant in eight countries.

Overall, the results indicate that there were more statistically significant cases of the real producer price decrease. Many countries in the region increased the nominal producer price of maize during the 1980s but the real producer price declined because most of these countries were unable to control domestic inflation.

6.1.2 Rice Prices

Rice also constitutes a large part of the staple diet for the Western African and Sahelian countries. The rice production in these regions has grown less than rice consumption per capita since 1970 (Topouziz,1991). Baring imports and government intervention, this should lead to a rise in rice prices over time. The data for the rice prices are available for eight countries during 1975-90. The annual growth rate of the ratio of producer price for rice and the domestic consumer price index was significant at the 10 percent and the lower level in five out of the eight countries examined. The real producer price of rice decreased significantly in all five countries, namely Senegal (0.86), Liberia (1.9), Ivory Coast (4.6), Gambia (4.7) and Zaire (15.9). The remaining three countries, (Nigeria, Tanzania, and Cameroon) exhibit a positive but statistically insignificant growth rate of real rice price. In the 1980s, Nigeria and Senegal show a significant positive in the growth rate of real rice price while Cameroon (-3.78), Liberia (-6.64) and Gambia (-6.53) exhibit a significant negative in the growth rate of real price. Tanzania (0.3) and Ivory Coast (0.53) show a growth rate of real producer that is positive but statistically insignificant.

The empirical evidence on real producer prices of rice presented in this study suggests that the movements of the nominal producer price of rice over time were unable to keep up with the rising domestic inflation for five of the Western African countries The cost of producing rice in these countries is higher than the cost of imported rice. As a consequence, governments of these countries imported rice to meet the rising demand in urban areas and sold the imported rice at a fraction of the price of locally produced rice (Malton,1988). The relatively low price of imported rice represents a bias against local rice producers and hence depresses the producer price of rice. In the 1980s, policy-makers in Nigeria and Senegal reduced consumer subsidies for rice and restricted imported rice. Producer prices of rice in these two countries increased significantly relative to the domestic consumer price index during the 1981-90 period.

6.1.3 Cassava Prices

Cassava is a staple root crop grown mainly in the Humid Central and Western African regions. The data on prices of cassava were available for 12 tropical African countries. Table 6.0 summarizes the annual growth rate of real producer prices for cassava. Over the whole sample period, the growth rate of the real producer price was statistically significant at 10 percent and lower levels in eight countries, and insignificant in four. Two countries (Central African Republic and Madagascar) experienced a significant increase in the real producer prices for cassava while six countries had a significant decrease in the cassava prices. In the latter group, Zaire (16.7 percent) experienced the highest growth rate of real price, followed by Tanzania (3.93) and Malawi (3.5). The real producer price in Nigeria, which produced over 25 percent of the Africa's cassava production in 1988, decreased by 2.7 percent per annum. In the 1980s, nine countries experienced a significant decrease in the real prices of cassava and only one country (CAR) showed a significant increase in the real cassava prices.

6.1.4 Sorghum and Millet Prices

Sorghum and millet are usually grown in less productive areas. These crops constitute the staple food crops in the rural areas of the semi-arid Sahelian countries. Evidence indicates that the production of sorghum and millet in semi-arid tropics has grown less than the population growth rate since the 1960's (Malton,1990). The growth rate of the real domestic producer price of sorghum was highly significant in six out of the ten countries examined and insignificant in the remaining four countries. The real producer price of sorghum decreased significantly in Tanzania, Cameroon, Ethiopia, Rwanda and Botswana and increased significantly just in Central Africa. In the 1980s, many of these countries exhibited a positive growth rate in the real producer price of sorghum.

The growth rate of real producer price for millet increased significantly in Niger and Nigeria and decreased in Gambia, Burkina Faso and Togo over the two sample periods.

In conclusion, the analysis of the food price performance indicates that most of the official producer prices for the food crops failed to keep pace with the increase in the domestic consumer price index over 1975-90 period. Most of the real producer prices of food crops (29 out of the 54 price series) examined in this study exhibited a significant negative growth rates, while only ten series exhibited a significant positive growth rates. In the 1980s, many countries in this sample have attempted to rationalize producer price incentives through either liberalizing the food market and/or increasing the official producer prices. These countries still showed a negative growth rate in the real food prices because most of these governments were unable to reduce the high inflation rate. An examination of the rate of growth in consumer prices for tropical African countries showed that the average inflation rate in tropical Africa was about 17 percent per year over the 1975-90 period. Most of the countries exhibited a double digit inflation rate ranging between 11 to 58 and only nine countries showed a rate of the inflation of less than 10 percent per annum.

6.2 Change in Real Export Crops Prices

A time-trend regression model described in chapter 3, equation 3.1 is used to compute the annual percentage growth rate of the real domestic producer prices and border equivalent prices. The border price is a unit value (expressed in domestic currency) free on board (f.o.b) of each individual export crop. The annual official producer and border prices are deflated by the national consumer price index to form the real prices. The annual percentage growth rate of the real domestic producer price and real border price for eight principal export crops are presented in Table 6.2 and summarized in Table 6.3.

6.2.1 Coffee Prices

The growth rates of real domestic producer prices and border prices of coffee are estimated for thirteen countries that rely on the export of coffee for their foreign exchange earnings. Annual growth rates in real domestic producer prices for coffee are statistically significant at the 10 percent and lower level in twelve countries and insignificant in one country (Togo). Over the whole sample period, real producer prices increased significantly in the Congo Republic (3.73 percent per year), Zaire (3.70) and the Central African Republic (3.37), and decreased in another nine countries (Table 6.2).

The annual percentage growth rate of real border prices for coffee are also estimated for thirteen countries in order to compare to the domestic producer prices. The estimated value of the real producer border prices for export for a commodity indicates the maximum value that producers could obtain on the world market. The growth rate of the real border prices varied across countries depending on the domestic inflation rate and

Table 6 2 Annual Compound Growth Rate ın Real Producer and Border Prices for a Sixteen Tropical African Countrıes, 1975-90

Commodity/ Country	Annual Percentage Growth Rate of: Real Domestic Producer Price	Border[(a)] Price in Domestic Currency	Average of the Ratio of Domestic Producer Price and Border Price (NPC) 1975-89	86-89
Coffee				
Congo Rep [1]	3 73***	-5 10*	0 52	1 09
Zaire[1]	3 70***	4 43	0 25	0 24
Central.A Rep	3 37***	1 43	0 27	0 34
Togo	2 01	-1 85	0 36	0 54
Rwanda	-1 37**	8 63***	0 76	0 81
Madagascar	-1 57*	0 19	0 36	0 38
Ivory Coast	-1 80***	-3 89*	0 50	0 72
Cameroon	-2 09***	-5 45**	0 58	0 90
Burundi	-3 10***	-8 67***	0 57	0 60
Tanzania	-4 24***	-2 75*	0 43	0 36
Liberia[1]	-5 13***	-2 17	0 62	0 79
Kenya[1]	-7 12***	-7 47***	0 88	0 95
Ethiopia	-7 79*	-6 15***	0 42	0 42
Cocoa				
Nigeria	6 26**	0 83	0 71	0 49
Togo	1 24	-6 73***	0 38	0 32
Congo Rep [1]	0 59	-11 77***	0 62	1 10
Ghana[1]	1 03	-3.11	0 47	0 25
Cameroon	-1 88***	10 59***	0 54	0 84
Ivory Coast	-2 55***	-10 05***	0 57	0 79
Liberia[1]	-6 32**	-8 91***	0 58	0 52

* Significant at the 10 % level ** Significant at the 5 % level

*** Significant at the 1 % level

Note [1].1975-89 period

[(a)] Real Border producer price of the export crops (expressed in domestic currency) is export unit value for a given commodity deflated by domestic inflation rate, measured by the National Consumer Price Index

NPC is nominal protection coefficient of the main export crops, measured as the ratio of real domestic and border producer prices

Table 6 2 continued

Commodity/ Country	Annual Percentage Growth Rate of: Real Domestic Producer Price	Border[@] Producer Price in Domestic Currency	Simple Average of the Ratio of Producer Price and Border price (NPC): 1975-89	86-89
Cotton				
Nigeria[2]	4 58*	7 43***	n a.	n a
Central A Rep	4 24***	-1 83*	0 72	0.82
Togo	0 16	-1.57	0.46	0 56
Sudan	-0 48	6.63***	0 80	0 61
Burkina Faso	-0 77	-3 14**	0 45	0.56
Cameroon	-0 94**	-0 83	0 40	0.90
Tanzania	-1.91***	0 57	0.83	0.49
Malawi	-2 28***	-4 96***	0 70	0 70
Gambia	-3 25***	-9 03***	0.41	0 51
Tea				
Tanzania	-2.79***	n a	0 20	0 10
Kenya	-4 69***	-6 49***	1 04	1 09
Malawi	5 99***	-8 12***	0.71	1.01
Rwanda	-4 52***	-5.44*	0 13	0 10
Tobacco				
Malawi[3]	-3 23***	1 97	0 55	0 26
Zambia	-1 71	6 53**	0.66	0 36
Groundnuts				
Gambia	-1 31	-1 01	0 62	0 71
Senegal	-1 65***	-3 7*	0 55	0 81
Banana				
Somalia	-2 11	2 59	0.38	0 33

Note 2 1975-86 3 Flue-Cured Tobacco Variety,1981-90 period.
@ Real Border producer price is an export unit value for a given commodity deflated by the inflation rate, measured by the National Consumer Price Index.
n a refers to not available
* Significant at the 10 % level
** Significant at the 5 % level
*** Significant at the 1 % level

Table 6 3 Summary of the Annual Percentage Growth Rates for the Main Export Corps (1975-1990)

Commodity	Positive Significant[a]	Negative Significant	Not Significant[b]	Total
		(number of price series)		
Coffee	3	9	1	13
Cocoa	1	3	3	7
Cotton	2	4	3	9
Groundnuts	0	1	1	2
Tobacco	0	1	1	2
Tea	0	4	0	4
Banana	0	0	1	1
Total	6	22	10	38

a Significant at the 10 percent and lower levels

b Not significant refers to the positive and negative annual percentage growth rate of real producer prices of the export crops that are not statistically significant at the 10 percentage confidence level transportation costs. For a given transportation cost, and exchange rate, countries with a higher inflation rate are likely to exhibit a negative growth rate of the real border price. The real border price of coffee declined significantly in eight of the thirteen countries examined in this study In examining the magnitude and direction of prices over time, it is important to note that the real domestic producer and border prices moved in the same direction for the eight countries, although the magnitude of the price changes was greater in the border prices than domestic producer prices. The real domestic and border prices of coffee in Kenya changed by the equal rate and moved in the same direction. The Kenyan marketing board used a "through-Put" pricing policy, that allowed world coffee prices to influence the domestic producer price. The coffee producers may have suffered more due to the world's lower coffee price than a lower domestic producer price caused by the domestic pricing policy.

6.2.2 **Cocoa Prices**

The growth rate of real domestic and border producer prices was estimated for seven cocoa exporters. The estimated coefficients of the domestic prices were statistically significant at the 10 percent level and lower in four countries and insignificant in the remaining three. The real producer price decreased significantly in Cameroon (-1.88), Ivory Coast (-2.55) and Liberia (-6.32). For these countries, the nominal producer prices for cocoa were unable to match the rising rate of inflation. Real producer prices increased significantly in Nigeria (6.3 percent) and insignificantly in Togo (2.1 percent) and the Congo Republic (0.59).

The growth rate of real border prices for cocoa expressed in domestic currency are also shown in Table 6.2. An examination of the exponential rate of change in prices reveals that real border prices experienced a significantly negative trend in all countries, except Nigeria over 1975-90. The pattern of real domestic and border prices showed that cocoa producers in Ghana, Cameroon, Ivory Coast and Liberia exhibited declining growth rates for the domestic producer price and border price. These two producer prices of cocoa moved in the same direction in Nigeria, but the growth rate of the real border prices was greater than that of domestic producer prices.

6.2.3 Cotton Prices

The data for cotton prices are available in nine African countries. The growth rates of the real prices for cotton was estimated over the 1975-90 period. The growth rates of the real cotton prices range between plus 4.6 to minus 3.2 percent per year. Real producer prices increased significantly by 4.3 percent per annum in Central African Republic and 4.6 percent per year in Nigeria. It decreased significantly in Cameroon (0.9 percent), Tanzania (1.91), Malawi (2.28) and Gambia (3 25). Including the nonsignificant estimates, the real producer price of cotton fell in six out of nine cases

The growth rates of real border prices for cotton fell in real domestic terms in the Central African Republic, Burkina Faso, Malawi and Gambia and increased in Nigeria and Sudan. The comparison of the pattern of domestic and adjusted world market prices reveals that cotton producers in Sudan and Tanzania saw their real prices decline, while the prices they could receive at world market increased. On the other hand, both prices decreased significantly in Malawi and Gambia but the rate of decline in domestic prices was lower than that of the border producer prices. Nigeria was the only country in this group where both domestic and border prices of cotton exhibited a positive growth rate.

6.2.4 Groundnut Prices

Complete information on the price of groundnut was available for the two main groundnut exporters in Africa: Senegal and Gambia. The rate of growth of real domestic prices for groundnuts fell significantly in Senegal and insignificantly in Gambia.

6.2.5 Tea, Tobacco and Banana Prices

The growth rate of the real producer prices and border prices for tea, tobacco and banana commodities are presented in Table 6.2. The regression results for tea indicate that the annual growth rates for both real domestic and border producer prices were negative in all four countries examined in this study. The growth rate of real domestic prices ranged from -2.8 percent per year in Tanzania to -6.0 percent in Malawi, while the growth rate the border prices for these countries ranged between -5.4 and -8.1. For most of the countries, the real domestic prices and real border prices declined at about the same rate. The findings tend to suggest that the countries (with the exception of Tanzania) have allowed world market prices to influence their domestic producer prices.

Real producer prices of tobacco are examined in two countries: Malawi and Zambia. The Malawian economy relies more heavily (than that of Zambia) on tobacco exports for its foreign exchange earnings. In Malawi, the real domestic producer price significantly dercreased by 3.23 percent per a year, while real border price increased (insignificantly) by 1.97. The real producer price decreased (insignificantly) in Zambia but the real border price of tobacco significantly increased by 6.5 percent.

Information on bananas prices was available for Somalia. The annual percentage growth rates of the real domestic producer price and the real border price of bananas for Somalia were both statistically insignificant.

Thus in summary, the preceding results indicate that for the eight main export commodities the estimated annual percentage growth rate in real producer prices increased in only six out of the thirty-eight cases considered in the study and decreased in twenty-two. The findings of the analysis of the producer price performance presented here, suggest that most of the governments failed to keep nominal producer prices in line with domestic inflation rates.

6.3 Analysis of Direct Effect on Producer Prices

The above discussion focused to some extent on the impact of government intervention on the growth of real producer prices. The result was based on trend analysis to examine the performance of producer price over time. This approach will not provide a complete and conclusive picture of the effect of direct and indirect price policy on agricultural incentives. To provide an alternative measure of government policy distortion on producer price incentives, the Nominal Protection Coefficient (NPC) method was used. The value of NPC indicates the direction and magnitude of policy distortions on producer incentives and resource allocations. This study used the range of NPC value proposed by Bayerlee and Sain (1986) to assess the pricing performance for the eight main export crops in tropical Africa. NPC values ranging between 0.85 and 1 15 reflect a policy environment free of taxation and subsidization. NPC values less than 0.85 implies a tax on producers of the commodity while a value of NPC greater than 1.15 reflects a subsidization. NPC coefficient is calculated as the average of the ratio of the domestic producer price to the export unit value was calculated for two selected periods: 1975-89 and 1986-89. The results for export crops in tropical Africa are listed in Table 6.2. The countries in the sample were then classified according to NPC values by commodities and presented later.

An examination of the average ratio of producer price and export unit value for coffee reveals that coffee producers in tropical Africa received, on average, 50 percent of the border price over 1975-89 period. The value of NPC was highest in Kenya (0.88), followed by Rwanda (0.76) and it was lowest in the Central African Republic (0.27) and Madagascar (0.36). As a result, Kenya is the only country that exhibited an agricultural pricing policy that did not tax or subsidize coffee producers. The remaining nine countries exhibited values of NPC less than 0.85, and hence had a policy environment that taxed coffee producers, directly or indirectly.

In 1986-89 period, most of the countries experienced higher NPC values with the exception to Tanzania. The average value of the NPC for coffee producers in the latter period was about 0.61. Three countries, Congo Republic (1.09), Kenya (0.95) and Cameroon (0.90) showed a neutral agricultural pricing policy environment. While the remaining seven countries showed NPC values that suggested a taxation environment. Many African countries have adopted policy reforms that increased producer prices of the crops by raising the nominal prices while the border equivalent producer prices for coffee fell. The increase in producer price and/or deterioration of the world prices results in the higher NPC values observed.

The average of the NPC values for cocoa showed that producers received only 55 percent of the border prices in 1975-89. Producers' share of the border price ranged between 0.71 for Nigeria and 0.38 for Togo. The values of the nominal protection coefficient are lower than 0.85, indicating that producers received only a small fraction of world prices. In the 1986-89 period, the share of the border price received by cocoa producers was 1.10 for the Congo republic, while the remaining seven countries have a NPC value that suggests an environment of taxation.

The estimates of nominal protection coefficients of cotton for the seven countries examined lie between 0.82 for Malawi and 0 42 for Gambia, averaging 0.61 during the whole sample period. These NPC values are lower than the 0.85 level, implying that all countries pursued a pricing policy that reduced the share of world prices obtained by the cotton producer. In 1986-89, the NPC values improved in Gambia, paying 91 percent of the world prices, implying a pricing policy free of distortion. The remaining countries have a value lower than 0.85.

The results of nominal protection coefficient for tea, groundnuts and banana are also given in table 6.4. The overall average NPC values for tea is 0.52. It is highest in Kenya (0.99) and lowest in Tanzania and Rwanda (0.12) over the whole sample period. In the 1986-89 period, the NPC values for Kenya and Malawi have shown that an environment of no taxation or subsidization. For groundnuts, the estimates of the nominal protection values show that Senegal (0.55) and Gambia (0.62) have both followed pricing policies that represent a bias against groundnut producers. Banana producers in Somalia received only 33 percent of the adjusted world price during 1975-89, suggesting a policy distortion.

Table 6 4 Nominal Protection Coefficient Results by Commodity, 1975-89

Category	**Coffee**	**Cocoa**	**Tea**	**Cotton**	**Groundnuts**	**Tobacco**	**Total**
Producer Taxed	12	8	3	8	2	2	35
Producer not taxed or Subsidized	1	0	1	0	0	0	2
Producer Subsidized	0	0	0	0	0	0	0
Simple Average NPC	0 5	0 6	0 5	0 6	0 6	0.6	
Number of Countries	13	8	4	8	2	2	37

Note According to Bayerlee and Sain (1986),
NPC < 0 85 implies taxation environment,
0 85 < NPC < 1 15 implies environment of neither taxation nor subsidy and
NPC > 1 15 indicates subsidization policy

The results of the NPC analysis are summarized in Table 6.4, for 1975-89 period. In assessing the policy distortions on incentives, the Nominal Protectioncoefficients are calculated in six main export commodities. This analysis indicates that there exists widespread policy distortion for most of the commodities African producers received, for instance, a small proportion of adjusted real border prices. On average, these shares ranged between 50 (for coffee and tea) to 60 percent (for cocoa) of the border prices depending upon the commodity under consideration. Since 1985, many African countries adopted policy reforms that increased domestic producer and although producer prices increased in most of the countries, the NPC values still indicated negative policy distortions.

The bias against agriculture resulting from government intervention is often blamed for poor agricultural growth in tropical Africa. This argument depends on the manner in which African farmers respond to policy measures as well as to how the government revenues from taxation on agriculture are used. The responsiveness of agriculture to incentives are estimated using an econometric framework that combines cross-section and time series data set. The results of the aggregate agricultural supply response to prices and other relevant variables will be discussed in the following chapter.

CHAPTER 7

EMPIRICAL RESULTS OF SUPPLY RESPONSE

7.0 Introduction

This chapter presents the empirical results for the response of export and food crop output to price and non-price variables, based on pooled cross-section and time series data. It discusses the results of the estimated coefficients of a dynamic equation with variable intercept presented in chapter five (equations 5.1 and 5.2). Separate supply equations are estimated for the export and food crops.

7.1 Empirical Results of Export Crop Supply Response

Aggregate export crop output is specified as a function of the price variable (two year average export price deflated by the current food price index), weather proxy, fertilizer use, disaster proxy, a time trend variable, food output lagged one period and country specific dummy variables. Estimated regression coefficients for the agricultural export supply response in tropical Africa and the four agro-climatic regions are presented in Table 7.0. The overall performance of the regression equations, based on the 20 countries over 16 years, is fairly high, suggesting that the explanatory variables are able to explain from 96 to 99 percent of the variation of the aggregate export supply[10]. Most of the estimated coefficients of the explanatory variables in the Tropical Africa (TA) equation are consistent with prior expectations.

---

[10] The Buse Raw-Moment R-square can be used as the goodness of fit measure when the regression equation is estimated using the original (rather than transformed data) data. According to Buse (1973), this R-square is an "ad hoc" measure since the constant term is suppressed in the estimated equation. The author showed that the measure is bounded by zero and one.

Table 7 0 Regression Coefficients of Export supply in Tropical Africa and Four Main Agro-climatic Regions, 1974-89

Dependent variable Export Crop Output

Independent Variables	Eastern and Southern Region (ESA)	Sudano-Sahel Region (SSA)	Western Africa Region (WA)	Central Africa Region (CA)	Tropical Africa (TA)
Producer Price [1]	11 132***	0 537	18 864***	2 070	2 118***
Lagged Dependent	0 439***	0 393***	0 477***	0 075	0 429***
Weather Proxy	-6 314	58 688**	8 751	-0 829	8 267
Disaster Variable	-0 312	-0 961***	0 024	0 139	-0 239*
Fertilizer Use	0 979***	-0 169	0 330	-2 298***	0 944***
Trend	1.314***	-1 010	0 703*	0 724	0 539***
Kenya	10 714				28 048***
Malawi	22 093***				44 385***
Tanzania	25 512***				41 043***
Ethiopia	27 839***				45 237***
Madagascar	36 049***				50 472***
Rwanda	57 573***				76 596***
Zambia	12 670***				29 449***
Sudan		86 466***			57 699***
Gambia		139 31***			90 290***
Senegal		110 74***			78 422***
Burkina Faso		107 96***			79 879***
Nigeria			23 702*		48 580***
Liberia			17 628*		23 911***
Ivory Coast			27 890*		46 357***
Ghana			11 645		40 791***
Togo			24 267*		49 246***
Central A.Rep				80 46***	45 385***
Congo Rep				77 001***	40 379***
Cameroon				84 122***	47 558***
Zaire				96 691***	53 987***
Number of obs	105	60	75	60	300
R-sq [2]	0 99	0 96	0 98	0 99	0 99
SSE	13 37	19 71	19 86	17 66	291 2

1 Producer price for the export is the ratio of the two year moving average (t,t-1) and current food price index
2 R-sq refers to the Buse raw moment R-Square.
*** implies statistically significant at 1 % level,
** implies 5 % level and
* indicates 10 % level of significance

The estimated coefficient for the dependent lagged value in the export supply equations is positive and significant at the 1 percent confidence level, with the exception of the Central African (CA) region. The adjustment coefficient for the Tropical Africa (TA) is 0 57 (i e 1-β_6) , presented in equation 5 1), implying that countries adjust, on average, 57 percent of the actual output level relative to the desired output level in a given year. The estimated adjustment coefficients vary slightly across the four agro-climatic regions and range from 0.52 in the Western Africa (WA) region to 0.61 in the Sudano-Sahel (SSA) zone The higher adjustment value observed in the SSA may be related to characteristics of the dominant export crops. The annual crops (such as groundnuts and cotton) are the main export crops in the SSA region, whereas perennial tree crops (such as coffee, cocoa and tea) dominate agricultural exports for Eastern and Southern Africa (ESA) and WA regions. Perennial crops have a longer maturation period relative to annual crops It is reasonable to expect that the actual output of the annual crops takes less time to adjust to the desired level than of the tree crops. Other studies on aggregate farm output response to price in some African countries have obtained estimates of adjustment coefficient that lie in the range found in this study. Sharma (1992), for example, used a partial adjustment model to estimate the aggregate agricultural output response to price and non-price variables in Kenya over the 1972-90 period and found that Kenyan farmers adjust on average 50 percent of the desired farm output in a given year.

The coefficient of the price ratio variable (two year average export price deflated by the current food price index) displays the expected positive signs in all equations, except that of the Sudano-Sahel. The estimated coefficient of the price variable is statistically significant at the 1 percent significance level for the TA, ESA and WA regions but is insignificant for the CA and SSA regions.

The direct short-run and long-run price elasticities for agricultural export supply for Tropical Africa (aggregate model) and four agro-climatic regions (regional models) are given in Table 7.1[11]. The overall short-run price elasticity for TA is 0.02 while the long-run elasticity is 0.04 ($\beta_1/(1-\beta_6)$). The elasticity estimates for the ESA is 0.12 in the short-run and 0.22 in the long-run. For the Western Africa region, the estimated short-run and long-run price elasticities are 0.23 and 0.43, respectively. The aggregate price elasticities of export and food supply are also estimated using double-logarithm functional form. The estimated short price elasticities of the export supply are statistically significant in Tropical Africa (0.04), ESA (0.11) and WA(0.27), and insignificant in SSA and CA (see appendix C1). As a result, the producer prices so defined influence current production decisions in Tropical Africa, ESA and Western Africa regions. Farmers in these regions can adopt agronomic practices that increase the quantity and improve the quality of agricultural export production.

The estimated price elasticities are, however, less than unity, indicating that although price incentives are necessary, they are not sufficient to substantially raise export crop production and hence agricultural exports. Moreover, the positive supply response to relative producer price (ratio of export price and food crop prices) obtained in the ESA and Western Africa regions support the view that there is resource competition between agricultural export crops and food crops.

---

[11] It should be noted that the production elasticity is equal to the supply elasticity only under the assumption of that a constant percentage of production is consumed. If this assumption is violated, the production elasticises (such as the ones reported in this study) underestimate the supply elasticities

Table 7 1 Aggregate Price Elasticities for Food and Export Supply in Tropical Africa and Four Main Agro-climatic Regions, 1974-89

	FOOD CROPS		EXPORT CROPS	
Country/ Region	Regional Model	Aggregate Model(TA)	Regional Model	Aggregate Model(TA)
Kenya	0 12	0 05	0 10	0 02
Malawi	0 15	0 06	0 16	0 03
Tanzania	0.16	0 07	0 11	0 02
Ethiopia	0.23	0 10	0 13	0 03
Madagascar	0.18	0 07	0 09	0 02
Rwanda	0.12	0 05	0.10	0 02
Zambia	0 11	0.05	0.13	0 03
East./Southern(ESA)	0 15	n a #	0 12	n a
Sudan	n s	0 05	n.s	0 02
Gambia	n s	0 06	n s	0 01
Senegal	n s	0 05	n s	0 01
Burkina Faso	n s	0 05	n s	0 02
Sudano-Sahel(SSA)	n.s	n a	n.s	n a
Nigeria	0 05	0 04	0 24	0.03
Liberia	0 11	0.09	0 12	0.01
Ivory Coast	0 06	0.05	0 19	0 02
Ghana	0.63	0.53	0 33	0.04
Togo	0 05	0 05	0 23	0.03
Western Africa (WA)	0.07	n.a	0 23	n a
Central A.Republic	n.s	0 07	n s	0 02
Congo Republic	n s	0.03	n s	0 03
Cameroon	n s	0 05	n.s	0 02
Zaire	n s	0 04	n s	0 05
Central Africa (CA)	n s	n a	n.s	n a
Tropical Africa (TA)	n.a	0 05	n a	0 02

Note. Aggregate price elasticities of the agricultural export or food supply for each country (ϵ_p) are calculated using the formula $\epsilon_p = (\delta Q/\delta P)(P_i/Q_i)$, where P_i and Q_i are the mean of the price and quantity, respectively, for i^{th} country The $(\delta Q/\delta P)$ is a common coefficient of the price variable from the aggregate (tropical) and regional regression models

n.a implies not applicable, and n s is not statistically significant

Separate price elasticities at the country level are also calculated, using the regression coefficients of the supply functions, and country specific values of price and quantity variables. These elasticity estimates are listed in Table 7.1, column 4. In general, price elasticities derived from the regional models are higher than the price elasticities calculated from the aggregate model. The derived price elasticities based on the regional models for Eastern and Southern African countries range from 0.09 (in Madagascar) to 0.16 (in Malawi), whereas those estimates derived from the coefficient of the aggregate model range between 0.02 and 0.03. The price elasticities derived from the regional regression equations are higher for the Western African countries relative to those of the ESA countries. These elasticity estimates extend from 0.12 in Liberia to 0.33 in Ghana while the price elasticities derived from the TA equation range from 0.01 in Liberia to 0.04 in Ghana. The export price elasticities for the SSA region derived from the aggregate model are between 0.01 (for Gambia and Senegal) and 0.02 (for Burkina Faso and Sudan). The elasticity estimates for the Central African countries range between 0.02 and 0.05.

The short-run price elasticities for export supply in Tropical Africa, ESA and WA regions are from 0.02 to 0.23, while the long-run price elasticities lie between 0.04 to 0.43. These estimates are comparable to previous empirical evidences on supply response to price in tropical Africa, which ranged between 0.06 and 0.3 (Bond,1981; Jaeger,1992; Binswanger et al. 1987).

The coefficient of the weather variable is positive in three of the five regression equations. The coefficient is positive and statistically significant at the 5 percent confidence level in the SSA and insignificant in all other cases. The results tend to suggest that the weather variable plays more important role in influencing the annual export agriculture in the SSA region, where price was found not have significant effect. The leverage of weather effect on agriculture is more pronounced in the semiarid region relative to the humid and sub-humid zones in tropical Africa In a recent study, Tuker et. al (1991) have pointed out that the raintall in the Sahel region was consistently below the long trend (1900-87) since the 1970s, partially explaining the declining agricultural production in the region.

The coefficient of the weather variable in the Tropical Africa equation remains statistically insignificant even when the regression equations are estimated using the instrumental variable technique (where output of export crop lagged two periods instead of one period, is used as an instrument) and the generalised least squares method (Error Component model). The coefficient is, however, significant at the 5 percent level in the pooled regression equation (i.e common intercept and common slope as shown in the appendix table D1). These results tends to indicate that the significance of the weather variable on the agricultural output diminishes, when the country effect is introduced in the supply equations. This finding is quite interesting because some of the pervious supply studies in tropical Africa found a strong weather effect on the aggregate agricultural output (Bond, 1983) and aggregate agricultural export supply (Jaeger,1992).

The estimated coefficient of the disaster variable is negative and statistically significant only in the SSA and the TA regions in the both functional forms (log-linear and linear). The significance of the coefficient in the SSA equation reflects the existence of ever present droughts which adversely affect the agricultural export output in the region. Droughts occur in the Sahel cyclically. It has been indicated that a long-lasting drought period (up to five years) happens in the Sahel five times in every century (La-Anyane,1985).

A fertilizer use variable is also included in the supply equations. The estimated parameter for the fertilizer use is positive and strongly significant at the 1 percent level in the TA equation. The calculated elasticity indicates that an increase in fertilizer consumption per hectare by 10 percent would increase the output of the export crops by 0.6 percent in Tropical Africa. The effect of the fertilizer use differs in the four main agro-climatic regions in tropical Africa. The coefficient is positive and statistically significant at the 1 percent level in the ESA region but insignificant in semi-arid SSA and humid WA regions. The coefficient is negative and significant at the 5 percent level in the CA region. The difference in the fertilizer effect on agricultural production across the agro-climatic regions tends to be associated with the share of fertilizer use in tropical Africa. The share of the fertilizer use per hectare for ESA region was approximately 52 percent of Africa's fertilizer consumption, while the combined share of the other three regions was 48 percent during the 1961-85 period (Dessai and Gandhi,1990). The Central Africa region had the lowest share of fertilizer use in tropical Africa.

The time trend variable used to capture the effect of changing technology is positive in all equations except the semi-arid SSA and CA equations. The coefficient is statistically significant in TA, ESA and WA regions. The coefficients of the time trend and fertilizer use variables are strongly significant in the ESA region, where roads are relatively improved and chemical nutrients and agricultural technology (such as high-yielding varieties) have been introduced to the agricultural export sector. The time trend variable as proxy for technical progress in cross-country supply variations assumes that state of technology grows at constant and identical rate in each country. However, in reality the adoption rate of a technological innovation depends on climatic condition and agricultural potential of a country.

Dummy variables for the intercepts are introduced in all regression equations to capture the time-invariant "country effects" on agricultural production. The effects may include soil potential. The estimated coefficients of the country intercepts are highly significant in all the regression equations (except those for Ghana and Kenya), indicating that the country effect is important in explaining the variation of agricultural export production.

7.2 Empirical Results of Food Crop Supply Response

This section presents the results of the aggregate food crop supply response for Tropical Africa and the four main agricultural regions over 1974-89 period. Aggregate food output is specified as a function of the last year's domestic terms of trade (domestic food price index deflated by national consumer price index), weather proxy, fertilizer use, disaster proxy, a time trend variable, food output lagged one period and country specific dummy variables. The estimated coefficients of the food supply equations are shown in Table 7.2[12]. The overall fit of the food equations is reasonably good, indicating that the

[12]. The regression coefficients of the covariance model (log-linear form) and the pooled model (both linear and log-linear functional form) for the food crop output response in the tropical Africa and four regions are provided in the appendix: Tables C2, D3 and D4.

Table 7 2 Regression Coefficients of Food Crop Supply in Tropical Africa and Four Main Agro-climatic Regions, 1974-89

Dependent variable Food Crop Output

Independent Variables	Eastern and Southern Region (ESA)	Sudano-Sahel Region (SSA)	Western Africa Region (WA)	Central Africa Region (CA)	Tropical Africa (TA)
Producer Price[1]	0 143***	-0 027	0 071*	0 008	0.059***
Lagged Dependent	0 374***	-0 071	0 312***	0 247***	0 230***
Weather Proxy	41 529***	119.55***	27 423***	17 710***	35 015***
Disaster Variable	-0 122	-0 060	-0 130	-1 129	-0.116
Fertilizer Use	0 572**	0 052	-0 138	2 600***	0.021*
Trend	1 267***	2 322***	3 393***	3 558***	2 637***
Kenya	44 015***				81 677***
Malawi	31 638***				52.414***
Tanz nia	36 873***				54 163***
Ethiopia	17 404***				27 751***
Madagascar	37 861***				55 681***
Rwanda	40 163***				50 451***
Zambia	52 701***				82 269***
Sudan		88 050***			49.839***
Gambia		87 565***			48 816***
Senegal		113 17***			66 109***
Burkina Faso		120 61***			71 195***
Nigeria			46 711***		61 064***
Liberia			36 670***		51 870***
Ivory Coast			39 400***		53.226***
Ghana			50.883***		66 905***
Togo			45 309***		60.795***
Central A Rep				61 771***	65 199***
Congo Rep				89.592***	100.85***
Cameroon				50 639***	58 483***
Zaire				51 702***	61 19***
Number of observation	105	60	75	60	300
R-Square[2]	0 99	0 99	0 99	0 99	0 99

Note. 1 Producer price is aggregate food prices lagged one period (t-1)

2 R-square refers to the Buse raw moment R-Square

explanatory variables in the equation explain over 90 percent of th variations of the food output.

The coefficient of the lagged dependent variable is positive and highly significant in all of the regression models except the SSA region The estimated adjustment coefficient of food production ranges between 0 63 to 0.77, indicating that food producers adjust from 63 to 77 percent of the desired food output in a given year depending on the agro climatic regions. The value of the coefficient is 0.75 in CA, 0.63 in ESA and 0.69 percent in WA. These in general are higher than the adjustment coefficients for the export crops involving more perennial crops.

As expected, the estimated coefficient for the expected real food price in Tropical Africa equation is positive, and statistically significant at the 1 percent confidence level This evidence suggests that the domestic terms of trade of food lagged one period is important in influencing the current year's food production in tropical Africa. The aggregate short-run price elasticity of the food crop output is 0 05 while the long-run price elasticity is 0.07 (see Table 7.1).

The effect of producer price on aggregate food crop output also varies among the main agricultural regions. Similar to the export supply response, the price coefficient is positive and statistically significant at the 5 percent and lower confidence levels in the ESA and WA regions but is insignificant in the SSA and the CA regions. The short-run food price elasticity estimate ranges from 0.07 in WA region to 0 15 in the ESA region, while the estimate of the long-run elasticity for the two regions is 0.10 and 0 23, respectively. The crop output response to food price is higher in the ESA relative to that of the WA region. On the other hand, the food price coefficient is not statistically different from zero in the SSA region and CA. The short-run price elasticities of food supply for each country in the sample are derived using the significant price coefficients (regional and Tropical Africa equations) and mean values for food price and output. The estimated short-run food supply elasticities for the ESA countries based on the regional model range between 0.1 to 0.23, whereas the elasticity estimates calculated from the Tropical Africa model (aggregate model) are between 0.05 to 0.10. For Western African countries, the price elasticity estimates from the aggregate and regional models are quite similar, ranging between 0.1 to 0.6. In this group, the highest elasticity estimate is obtained in Ghana (0.5 to 0.6), while the elasticity estimates of the remaining four countries range between 0.05 to 0.10. As expected the food crop supply elasticities are higher than the perennial export crop supply elasticities.

The estimated price elasticities for Sudano Sahelien and Central African countries are calculated from the price coefficient of the TA equation since the price coefficients for the regional models are not statistically different from zero. These elasticities range between 0.04 to 0.07 for the Sudano-Sahelien countries and 0.05 to 0.06 for the Central African countries.

Overall, the elasticity estimates for tropical Africa are 0.05 in the short-run and 0.07 in the long-run. However, the responsiveness of food producers to price incentives varies among the main agricultural regions. The short-run price elasticity for the food supply is found to be 0 15 in the ESA and 0.07 in Western Africa, while the estimated price elasticity is not different from zero for the Sudano-Sahel and Central Africa regions.

The estimates of the aggregate price elasticity presented here suggest that food producers in tropical Africa, ESA and WA regions are responsive to the changes in the domestic terms of trade. These results are consistent with the previous results on the food production. Bapna et al. (1984) estimated an aggregate short-run price elasticity of food output crop for the semi-arid tropical regions in India using cross section and time series data. They found aggregate price elasticities for food crops ranging from 0.05 to 0.09. These values are equal to the elasticity estimates found in tropical Africa and Western Africa, but are lower than the elasticity estimates obtained in the ESA region. This finding seems to support Binswanger's (1989) argument that "the short-run supply elasticities for Sub-Saharan Africa are no lower than for other areas".

The food supply response to output price obtained in this study was inelastic, implying that price policy alone can not prompt a substantial increase in agricultural food production in tropical Africa. Investment in agricultural technology is also needed for increased agricultural growth. The estimated elasticity of the weather proxy variable is positive and highly significant at the 1 percent level for all the food equations. The estimated coefficients of the rainfall range 0.001 to 0.006, indicating that a 10 percent drop of the actual cereal yield from it's trend will lead to 0.01 to 0.06 percent of the food production depending on the region. The coefficient of the "Disaster" proxy is negative as expected but does not emerge statistically different from zero in all regression equations. It has been retained in the models to preserve the consistency of the models with the export crop supply response models.

The coefficient of the fertilizer use variable is positive and statistically significant at the 1 percent confidence level for the TA, ESA and CA regions, but insignificant in the semi-arid SSA and in the humid WA regions. The magnitudes of the significant fertilizer coefficients range from 0.03 to 0.06, suggesting that a 10 percent change in fertilizer use will lead to a 0.3 to 0.6 percent change in the food production.

The estimated coefficient on the time trend variable is also positive and strongly significant at the 5 percent or lower level in all the equations, showing that technical and institutional factors are important in improving food crop productivity in these regions. The rate of change in agricultural productivity is, however, low. The magnitude of the coefficients range from 0 09 in ESA to 0.25 in Western Africa. Investments in non-price factors such as road infrastructure, research and extension, and improved food markets can raise food productivity and increase region's productive capacity to feed it's rising population.

A dummy for the variable intercept is also included in the regression equations to represent factors that are specific to each country. The estimated coefficients for dummy variables are positive and statistically significant in all equations. Similar to the export equation, the inclusion of the intercept dummy variables in the econometric model improves the consistency and efficiency of the parameter estimates in the food supply model. It is difficult to interpret the coefficient of the dummy variable since it attempts to represent all un-observable and time-invariant factors that influence agricultural productivity.

CHAPTER 8

SUMMARY AND CONCLUSION

8.0 Introduction

The performance of African agriculture deteriorated in the 1970s and 1980s. Per capita food production in tropical Africa declined by 0.9 percent and the market share of the ten main agricultural export commodities in tropical Africa fell by about 4.5 percent per annum. Agricultural pricing policies used by African governments have been blamed for the agricultural crisis. The effect of the policy measures on producer incentives and how producers respond to incentives is relevant to the understanding of agricultural problems and reversing the declining agricultural trends.

After reviewing the price performance of the staple food and main export crops in tropical Africa, this thesis examined the impact of agricultural price and other factors on food and export crop production. The dual objective of the study was to investigate the degree of responsiveness of African farmers to incentives in different agro-climatic regions. To accomplish these objectives, the study is divided into two parts. The first part focused on producer price performance over time while the second part focused on agricultural supply response to price and non-price factors.

8.1 Findings Related to Government Policy Distortions

The effect of the government intervention on producer prices was estimated using a exponential growth rate model. Average Nominal Protection Coefficients were also calculated. Real producer prices, as measured by official producer prices deflated by national consumer price indices, were used as measure of price incentives since the producer price is the main focal point of government intervention. It was postulated that if the policy-maker pursues a pricing policy that favours producers relative to consumers, real producer prices will exhibit a positive trend. On the other hand, when government intervention represents a bias against agriculture, real producer price is expected to show a negative price trend. The analysis lead to several important conclusions.

1. The analysis of the annual percentage growth rates for the real food prices indicates that there are more countries that exhibit a significant decrease (twenty-nine out fifty-four cases) in real food prices series than a significant increase (ten price series) over the 1975-1990 period. The remaining fifteen price series were not statistically different from zero.

2. With regard to the export commodities examined, the estimated annual percentage growth rates were positive in six out of the thirty-eight cases and negative in twenty-two price series. Official producer prices of export crops for most of the countries have been unable to keep pace with the increase in consumer prices. This pattern is common to almost all of the commodities.

3. Further, the analysis of the average nominal protection coefficient (NPC) of the export crops confirms that there is widespread policy distortion for most of the export commodities. African producers receive a small proportion of the real border prices, ranging between 50 to 60 percent of the border prices depending the commodity under consideration. Since 1985, many African countries have adopted price policy reforms that increase domestic producer prices. Despite this effort, the NPC values still show an environment of possible taxation during this period.

8.2 Findings of Aggregate Price Elasticity Estimates

The impact of price distortions resulting from government intervention depends on the manner in which African producers respond to policy measures and how the government revenues from the tax on agriculture are used. If agricultural producers are highly responsive to price incentives, price policy that taxes their products can have a strong impact on producer incentive, which in turn, will reduce agricultural productivity. On the other hand, producers can be constrained by the lack of public expenditure on research and extension services, improved road infrastructure, assured water supply and input distribution. The provision of these factors is important for African farmers to respond to price incentives. To examine the responsiveness of agriculture to producer prices and non-price variables, an econometric dynamic supply equation with variable intercept is estimated using annual cross section and time series data from 20 tropical African countries during 1974-89. This econometric model is selected from the various panel data models based on the Hausman specification test statistic. Aggregate food and export crop output are regressed on the relative output price, weather proxy variable, fertilizer use, disaster variable, technology proxy variable, lagged dependent variable and dummies for the variable country intercepts.

Analysis of the results of the agricultural aggregate (food and export) crop output response to producer price and non-price variables leads to the following findings and conclusions.

1). The estimated aggregate price elasticity estimates for both export and food crop supply in tropical Africa are positive and significant, suggesting that agricultural producers in tropical Africa do positively respond to price incentives. The degree of response to price, however, is small and less than unity. The estimated price elasticities for aggregate exports are 0.02 in the short-run and 0.04 in the long-run long. For food crops, the short-run and long-run price elasticities are 0.05 and 0.07, respectively.

2. Comparing the estimated coefficients of the price variable and price elasticity estimates of the main agro-climatic regions reveals that agricultural producers in the ESA and Western Africa regions are more responsive to price incentives relative to their counterparts in the Sudano-Sahel and Central Africa regions. This result is valid for both the aggregate export and food crop output supply functions.

3. The positive export output response to relative price observed in the ESA and Western Africa regions leads to the conclusion that the export and food crop production do compete with each other for agricultural resources. 4. The price coefficient and elasticity estimates of the food and export crops in the Semiarid Sudano-Sahel region are not statistically different from zero. The weather variable and disaster variable are strongly significant in the SSA region, indicating their relative importance over price incentives in determining agricultural output. Investment in low cost irrigation schemes to counteract adverse weather conditions is, therefore, essential to increase for agricultural output in the region.

5. The coefficient of the trend variable is positive and significant in most of the aggregate supply functions. This evidence indicates the importance of the non-price factors in increasing agricultural output in tropical Africa. Increasing the supply of the public factors such as road infrastructure, research and extension, improving food markets and input distribution can increase agricultural production in tropical Africa. Hence supporting the hypothesis that provision of non-price "technology" factors along with the favourable price incentives are

more effective in raising the agricultural production.

8.3 Policy Implications of the Study

The findings of this thesis indicate that government intervention in tropical Africa in agricultural marketing and pricing has distorted agricultural production incentives. Pricing policy reform that reduces government distortion in the agricultural market can be an important step toward inducing agricultural producers to raise agricultural output and adopt new agronomic practices that will improve the quality and quantity of crop output.

The price incentive alone, however, may not induce any substantial increase in agricultural productivity since the aggregate crop output response to price incentives is very low. Agricultural productivity in tropical Africa is constrained by the absence of appropriate agricultural technologies. The low short-run aggregate price elasticity often obtained in the agricultural supply response literature clearly mirrors the lack of roads, transport facilities, lack of research and extension, and shortage of an assured water supply. Provision of these non-price factors is the key for raising agricultural productivity and production in Africa.

The main agricultural regions in tropical Africa differ, however, in their agricultural constraints and agricultural policies need to recognize the constraints of the each region in order to be more effective in raising agricultural output. In some regions such as SSA the lack of soil moisture and low soil fertility are the main constraints for expanding agricultural production. Increased water supply and improved fertilization are important for expanding agriculture there. Producers in Eastern and Southern Africa, and Western Africa respond positively to price incentives. As a result, favourable pricing policy and provision of good roads and appropriate research and extension services are needed to increase agricultural production in these regions.

8.4 Limitations of the Study

Although this study attempts to contribute the assessment of the agricultural supply response in tropical Africa, there are several limitations. These shortcomings relate mainly to data problems, which have an impact on the depth and relevance of price analysis. First, the domestic price and production data used in the study are taken from official sources. Although the data are the best available, they do not reflect farm gate prices (output) due to the lack of transportation and other marketing costs. Second, the nominal protection coefficient analysis is used to examine producer price incentives. While this method is a common measure of price incentive, it considers only output price and not input prices. Moreover, the domestic prices of tradeable commodities are derived from the appropriate world price using a fixed official exchange rate. The domestic currencies are controlled and overvalued. As a result, the rate might not be a good indicator of the opportunity cost of foreign currency. An alternative such as the effective exchange rate can be used in order to estimate the effective protection coefficient if data on input prices are available. Also, the method used in aggregating data is always open to criticism and the estimated coefficients may lack efficiency due to aggregation bias.

Similar reservations need to be expressed in the use of the dynamic equation to estimate the response of the aggregate crop output to price and non-price variables. The covariance model was used to estimate relevant parameters. The coefficients are unbiased and consistent, only when the lagged dependent variable among the explanatory variables is not correlated with error terms. If this underlying assumption is violated, the estimated parameters become less robust and the estimation methods such as three stage least squares and maximum likelihood need to be employed in order to obtain more consistent and efficient parameter estimates. These techniques require, however, a large sample size, and also are not free from additional estimation problems. However, improvements in data and estimation techniques may produce better results.

REFERENCES

African Development Bank. (1990). African Development Report. Abidjan, Ivory Coast.

Alexandratos, N. (ed.). World Agriculture: Towards 2000 An FAO Study. Food and Agriculture Organization of the United Nations, by Belhaven Press, London, 1988, Table A.3.

Anderson, W. and Hsiao, C. (1982). "Formulation and Estimation of Dynamic Models Using Panel Data." J. of Econometrics. Vol.18. pp.47-82.

Askari, H. and Cummings, J. (1977) "Estimating agricultural supply response with the Nerlove model: A survey." International Economic Review 18, pp.257-92.

Arellano, M. (1993). "On Testing of Correlated Effects with Panel Data." J. of Econometrics, Vol.57, pp.87-97.

Balastra, P. and Nerlove, M. (1966). "Pooling Cross Section and Time Series Data in the Estimation of Dynamic Model: The Demand for Natural Gas." Econometrica. Vol.34, No.3. pp.585-612.

Bapna, S. (1980). Aggregate Supply Response of Crops in a Developing Region, Delhi, Sultan chand and sons.

Bapna, S. Binswanger, H. Quizon, J. (1984). "Systems of Output Supply and Factor Demand Equations for Semi-Arid Tropical India." Indian. J. Agric. Econ. Vol.39,No.2: pp.179-202.

Bateman, W. (1965) "Aggregate and regional supply functions for Ghanian cocoa". J. of farm economics vol.47. pp.348-401.

Bayerlee, D and Sain, G. (1986). "Food Pricing in Developing Countries: Bias against Agriculture or for Urban Consumers?" Amer. J. Agr. Econ. Vol.68, no.4, pp.961-969.

Binswanger, H., Mundlak, Y., Maw-Cheng Y., and Bowers, A. (1987). "On the determinants of cross-country aggregate agriculture supply". J. of econometrics 36, pp.111-31.

Binswanger, H. "The policy response of agriculture". Proceedings of the World Bank annual Conference on Development Economics 1989. World Bank, Washington, D.C. Processed.

Bond, M. (1983). "Agricultural Response to Prices in Sub-Saharan Africa." International Monetary Fund Staff Papers 30, no.4: pp.703-26. Washington D.C.

Bumb, B. (1991). "Fertilizer Supply in Sub-Saharan Africa" In Tishibaka,T. and Baanante, C. (Editors). Fertilizer Policy in Tropical Africa: Workshop Proceedings. Lome, Togo, April, 1988. pp.137-148.

Buse, A. (1973). "Goodness of Fit in Generalized Least Square Estimation". The American Statistian. June 1973, Vol.27, No.3, pp.106-108.

Chhibber,A (1988). "The Aggregate Supply Response in Agriculture: A survey." In S.Commander, Ed., Structural Adjustment In Agriculture: In Theory and Practice. London: James Currey Publishers.

Cleaver.K. (1993). A Strategy to Develop Agriculture in Sub-Saharan Africa and Focus for the World Bank. World Bank Technical Paper, Africa Technical Department Series. No.203, 1993.

Delgado, C. and Mellor, J. (1984). "A Structural View of Policy Issues in African Agricultural Development." Amer. J. Agr. Econ. 66(5), December, 1984, pp.665-670.

Desai, G. and Gandhi, V (1991). "Fertilizer Consumption in Sub-Saharan Africa: An Analysis of Growth and Profile of Use." In. Tishibaka,T. and Baanante, C. (Eds.) Fertilizer Policy in Tropical Africa: Workshop Proceedings. Org. by IFDC and International Food Policy Research Institute (IFPRI). Togo,pp.119-132.

Domberger, S. (1987). "A Disaggregated Analysis." J. Polit. Econ. Vol.95, pp.547-67.

Eicher, C. and Baker, D. (1990). "Agricultural Development in Sub-Saharan Africa: A Critical Survey." In Martin (editor). Survey of Agricultural Development Literature. Minnesota University Press. Vol. 4. pp. 3-228.

Food and Agriculture Organisation (1986). Atlas of African Agriculture - African Agriculture in the Next 25 Years. Rome: FAO.,1986.

Food and Agriculture Organisation (1990). State of Food and Agriculture. FAO, Rome, 1990, pp.207.

Food and Agriculture Organisation (1991, Production Yearbook. FAO, Rome, Italy.

Fuller, W. and Battiese, G. (1974). "Estimation of Linear Models with Cross-Error Structure." J. of Econometrics Vol.2, pp.67-78.

Ghai,D. and Smith, L. (1987). "Agricultural Prices, policy and Equity in Sub-Saharan Africa. Lynne Rienner Publisher, Inc, Boulder, Colorado.

Godfrey, L. (1988). Mis-specification Tests in Econometrics. The Large Multiplier Principle and Other Approaches. Cambridge University Press.

Gray, John. (1992). "Maize Marketing in Eastern and Southern Africa."Food Policy. December,1992, pp.408-419.

Greene, W. (1990). Econometric Analysis. Macmillan Publishing Company and Collier Macmillan Publishers. pp.561-577.

Griliches, Z. (1959). "The Demand for Inputs in Agriculture and Derived Supply Elasticity." J. of Farm Economics, Vol.41. pp. 309-322.

Hallam, D. (1990). Econometric Modeling of Agricultural Commodity Markets. Routledge Press, London. pp.51

Hanrahan, C. and C. Christensen. Food policy in Sub-Saharan Africa. paper prepared for African Studies Association Meetings. Mimeographed USDA ERS, Washington,D.C.,1981.

Harrison,P. (1989) "Sustainable Growth in African Agriculture" in Background Paper. The long Term Prospective Study of Sub-Saharan Africa. Vol.2: Economic and Social Policy Issue. World Bank. Washington.D.C.

Hausman, J. (1978). "Specification Test in Econometrics." Econometrica. Vol.46. No.6. pp.1251-1271.

Heady, E. (1957). "Uses and Concepts in Supply Response Analysis." Agricultural Supply Functions: Estimating Techniques and Interpretations. (ed.) Heady, et al. Iowa State University Press Ames, pp.11-14.

Hsiao, C. (1986). Analysis of Panel Data. Econometric Monographs, No.11 Cambridge University Press.

Jaeger, W. (1992). "The Effects Of Economic Policies on African Agriculture." World

Bank Discussion Paper, African Technical Department Series, no.147, 1992.

Jaeger, W. and Humphrey, C. (1988). "The Effect of Policy Reform on Agricultural Incentives in Sub-Saharan Africa " Amer. J. Agr.Econ Vol.70, No.5. (December 1988), pp. 1037-1043.

Jones, W. (1984) "Economic Tasks for Food Marketing Boards in Tropical Africa." Food Research Institute Studies. Vol.XIX, No.2,1984. pp.113-137.

Johonston,B. and Mellor, J. (1961). "The Role Of Agriculture in Economic Development" American Economic Review, 51, pp.566-593.

Judge, G. Griffiths, R. Lee, T. and Lutkepol, H. (1988). An Introduction to the Theory and Practice of Econometrics, New York: Wiley, 1988.

Junankar, P. (1989). "The Response of Peasant Farmers to Price Incentives: The Use and Misuse of Profit Functions." J. Dev. Stat., Vol.25 (January,1989)

Krishna, R. (1982). "Some aspects of agricultural growth, price policy and equity in developing countries."Food Res. Inst. Stud. 18:219-260.

La-Anyane, S. (1985). Economics of Agricultural Development in Tropical Africa. Chichester: John Wiley, 1985, pp. 1-7.

Lele, Uma, (ed.) (1989). "Managing Agricultural Development in Africa. Lessons from Experience." MADIA Discussion Paper 2, World Bank, Washington D.C.,1989, pp.60-85.

Lofchie, M. (1989). The Policy Factor: Agricultural Performance in Kenya and Tanzania. Boulder: Lynne Rienner Publishers.

Lutz, E. and Scandizzo, L. (1980). "Price distortions in Developing Countries: A bias against agriculture." Euro. Review. Agr. Econ. vol.7 no.1 1980. pp.5-27.

Maitha, J.K. (1970). "Productivity response to price: a case study of Kenyan coffee". Eastern Africa Economic Review. Vol 2. no.2, December 1970.

Malton, P. and Spencer, D. (1984) "Increasing Food Production in Sub-Saharan Africa Environmental Problems and Inadequate Technological Solutions " Amer. J. Agr. Econ. 66(5), December, 1984, pp.671-676.

Malton, P. (1990) "Improving Productivity in Sorghum and Millet in Semi-Arid Africa." Food Research Institute Studies, Vol. XXII, No.1, 1990. pp.1-25.

Mundlak, Y. (1978). "On the Pooling of Time Series and Cross Section Data." Econometrica, Vol.46, No.1, pp.69-85.

Nerlove, M. (1958). "The dynamics of supply: estimation of farmers response to price". John Hopkins University Press, Baltimore, MD.

Organization Of African Unity (1985). Africa's Priority Programme for Economic Recovery, 1986-90. Addis Ababa, Ethiopia, 1985.

Parks, R. (1978). "Inflation and Relative Price Variability." J. of Political Econ. Vol.86, pp.79-95.

Paulino,L (1986). "The Evolving Food Situations." In Mellor, J. Delagado,C.and Blakie, M. (Editors). Accelerating Food Production in Sub-Saharan Africa. International Food Policy Research Institute (IPFRI). The Johns Hopkins University Press, Baltimore and London. pp.23-38.

Peterson W. (1988). "International Supply Response." Agricultural Economics, 1988(2), pp.365-74.

Rao, M. (1988). "Agricultural Supply Response: A Survey." Agric. Econ., Vol.3, pp.1-22.

Sed-Elmi, O. (1992). Agricultural Supply Response to Prices in Sub-Saharan Africa: A Survey. Unpublished Thesis. Concordia University, 1992.

Schultz, T.W. (1978). "On economics and politics of agriculture." In: T.W.Schultz (Editor), Distortions of agricultural incentives, Indiana University Press, Bloom IN. pp 3-23.

Sharma, K, (1992). "Aggregate Farm Supply Response in Kenya." Eastern Africa Economic Review. pp.92-101.

Tapouzis, D (1991). "Relying on Rice." Africa Report. January-February, pp.44-46.

Taylor, D. and Phillips, T. (1991). "Food Pricing Policies in Developing Countries: Further Evidence on Cereal Producer Prices." A.J. Agr. Econ. Vol.73, no.4, pp.1036-1041.

Timberlake, L.(1985). Africa Crisis: The Causes and the Cures of Environmental Bankruptcy. London: Earthcan, 1985), pp.45.

Ter Kuile, C. (1986). "The Humid and Sub-humid Tropics." In Mellor,J. Delagado, C. and Blakie, M (Editors). Accelerating Food Production in Sub-Saharan Africa. IFPRI. The Johns Hopkins University Press, Baltimore and London. pp.97-108.

Tshibaka, T. (1986). "The effect of trade and exchange rate policies on agriculture in Zaire" Research Report, International Food Policy Research Institute (IPFRI) (1992). Nov. 1986.

Tuker, H., Dregne, W. and Newcomb, W. (1991). "Expansion and Contraction of the

Sahara Desert from 1980-1990." Science, Vol.253, pp.299-301.

UNDP/World Bank (1992). African Development Indicators, United Nations Development Programme (UNDP)/World Bank, 1992. Washington, D.C.

UNDP/ World Bank, (1989). African Economic and Financial Data, UNDP/World Bank, 1989. Washington, D.C

United Nations Conference on Trade and Development (UNCTD,1991) Handbook of International Trade and Development Statistics. Yew York, 1991, pp 467

United Nations (UN). Statistical Yearbook. New York, ,1982-1991.

United States Department of Agriculture (USDA,1986). World Indices of Agricultural Food Production, 1977-86 ERS, Washington D.C.

United States Agency of International Development (USAID), (1992). Disaster History, Significant Data on Major Disasters WorldWide, 1990-Present, Washington, D.C

World Bank (1989) Sub-Saharan Africa: From Crisis to Sustainable Growth. Washington, DC.

World Bank (1981). Acceleration of Food Production in the Sub-Saharan Africa". World Bank, Washington, D.C , 1981.

World Bank (1986). World Development Report 1986. Oxford Uni.Press, N.Y, .

World Bank(1990). World Development Report 1990. Oxford Uni Press, N.Y,

APPENDIX A: EXPORT AND FOOD COMMODITIES USED IN THE STUDY

Appendix A The export and food crops for Tropical African countries used in the study

Region/ Country	Export Crops	Food Crops
Eastern and Southern Africa		
Kenya	Coffee, Tea	Maize, Sugar
Malawi	Tobacco, Cotton	Maize,Groundnuts
Tanzania	Coffee, Tea, Cotton	Maize, Rice, Cassava, Sorghum
Ethiopia	Coffee	Maize, Sorghum ,Barely
Madagascar	Coffee, Clover, Vanilla	Cassava, Rice
Rwanda	Coffee, Tea	Maize, Sorghum
Zambia	Tobacco, Cotton	Maize, Cassava, Wheat
Sudano-Sahel Region		
Sudan	Cotton	Sorghum, Groundnuts, Sesame
Gambia	Groundnuts, Cotton	Millet, Rice
Senegal	Groundnuts, Cotton,	Sorghum, Rice
Burkina Faso	Cotton	Sorghum, Maize, Groundnuts
Central African Region		
Central A Rep	Coffee, Cotton	Cassava, Sorghum, Groundnuts
Congo Rep	Cocoa, Coffee	Cassava, Maize
Cameroon	Cocoa, Coffee, Cotton	Cassava, Rice, Maize
Zaire	Coffee, Palm oil	Cassava, Maize, Rice
Westernern African Region		
Nigeria	Cocoa,Cotton	Maize, Millet, Groundnuts, Cassava
Liberia	Coffee	Cassava
Ivory Coast	Cocoa,Coffee	Cassava, Rice
Ghana	Cocoa	Cassava, Maize, Groundnuts
Togo	Cocoa, Coffee, Cotton	Cassava, Maize,Millet

Note The classification of the crops is the one reported in the African Financial and Economic Data (1989) In this source, export and food crops are classified and ranked according to the contribution of export earning or calorie intake of 1986/87 year

APPENDIX B: VARIOUS ECONOMETRIC EQUATIONS ESTIMATED FOR SPECIFICATION TESTS

Appendix B Table B1 Estimated Coefficients of Various Methods for Food Crop Supply Responses in Tropical Africa, 1974-89

Independent Variable	Estimation Method[1]			
	PR	CV	GLS	IV
Producer Price	2.477**	1 879**	1 728**	1 474
Lagged Dependent	0 773***	0 393***	0 392***	0 002
Weather Variable	15 142**	8 291	7.916	8 684
Disaster Proxy	-0 026	-0 201	-0 182	-0 099
Fertilizer Use	0.187**	0 948***	0 933***	1 294***
Trend Variable	0.443***	0 605***	0.693***	1 021***
Constant	17 161***	n/a	45 64***	n a
Number of Obser	300	300	300	280
Buse R-square	0 99	0 42	0 53	0 25
SSE	155 7	172.2	152 4	135 7

1: PR = Pooled Regression CV = Covariance Model GLS = Generalized Least Square IV = Instrumental Variable Model

Note. The specification of variables varies with the method of estimations The data used in the Pooled regression model are the original values except for the weather variable (log-form)

For the CV model, the data are deviations of each variable from it's country mean, so the individual country intercepts are eliminated The result of the CV based on the transformed data are equivalent to the results of the model based on the orginal data (level) (as is shown in the Table 7 0)

The magnitude of the estimated coefficients of the data are transformed using the variation of the within-country and between variation as weight to estimate GLS

For the Instrumental variable method (IV), the data are the first difference of the variables.
n.a stands for not applicable

*, **, *** imply significant at the 10, 5 and 1 percent level, respectively

Appendix B Table B2 Estimated Coefficients of Various Methods for Export Crop Supply Responses in Tropical Africa, 1974-89

Independent Variables	Estimation Method[1]			
	PR	CV	GLS	IV
Producer Price	0 020	0 045***	0.055***	0.140***
Lagged Dependent	0 547***	0.239***	0.323***	0 008
Weather Variable	28.~21***	34.63***	33 58***	57.23***
Disaster Proxy	-0 0/1	-0.11	-0.091	-0 070
Fertilizer Use	0 000***	0 035	0.015	0 671*
Trend Variable	0.973**	2.620***	2 377***	1.6081***
Constant	13.500*	n.a	76 99	n a
Number of Obser	300	300	300	280
R-square	0 999	0 68	0.68	0.60
SSE	149 5	284 1	153 6	155 5

1 PR = Pooled Regression CV = Covariance Model GLS = Generalized Least Square IV = Instrumental Variable Model.

The specification of variables varies depending on the method of estimations. The data for each variables are in original values except to weather variable in PR

For the CV model, the data are deviations of each variable from it's country mean, so the individual country intercepts are eliminated The result of the CV based on the transformed data are equivalent to the results of the model based on the orginal data (levels) (as is shown in the Table 7 2)

For the GLS approach, the data are transformed using the variation of the within-country and between variation as weight

For the Instrumental variable method (IV), the data are first difference of the variables
n.a stands for not applicable

*, **, *** imply significant at the 10, 5 and 1 percent level, respectively

APPENDIX C REGRESSION COEFFICIENTS FOR EXPORT AND FOOD CROP OUTPUT RESPONSE IN TROPICAL AFRICA AND MAIN AGRO-CLIMATIC REGIONS (DOUBLE LOGARITHM FUNCTIONAL FORMS)

Appendix C Table C1 Coefficients of Covariance for Export Crop Supply Responses in Tropical Africa and four main Agro-climatic regions, 1974-89

Dependent variable Export Crop Output [1]

Independent Variables	Eastern and Southern Africa (ESA)	Sudano-Sahel Africa (SSA)	Western Africa (WA)	Central Africa (CA)	Tropical Africa (TA)
Producer Price [2]	0 108***	0 017	0 270***	-0.016	0.036***
Lagged Dependent	0 308***	0 316***	0.388***	0.204	0 374***
Weather Proxy	-0.007	0 452***	0 071	-0.135	0.085
disaster Variable	-0 002	-0 006***	0 001	-0.061	-0.002**
Fertilizer Use	0.083*	0.121	-0.01	-0.003	0.007
Trend	0.020***	-0 003	0.014**	-0 001	0.007***
Kenya	2 240***				2 826***
Malawi	2 215***				2.816***
Tanzania	2.260***				2.734***
Ethiopia	2.305***				2.749***
Madagascar	2.425***				2.817***
Rwanda	2.702***				2.996***
Zambia	2.119***				2 760***
Sudan		2 292***			2.869***
Gambia		2.505***			3 185***
Senegal		2 416***			3 042***
Burkina Faso		1.436***			2 969***
Nigeria			2 765***		2.810***
Liberia			2.781***		2.502***
Ivory Coast			2 824***		2.815***
Ghana			2 650***		2.734***
Togo			2 753***		2.784***
Central A R				3 973***	2 718***
Congo Rep				3 932***	2 636***
Cameroon				4.069***	2 759***
Zaire				4.33***	2 838***
Number of Obser	105	60	75	60	300
R Sq	0.98	0.99	0 99	0.99	0.99

1 the total export production, producer prices, weather variable and fertilizer uses are expressed in logarithm.

2. producer price for the export is ratio of moving average of two year (t,t-1) and Current food price index.

*, **, *** imply significant at the 10, 5 and 1 percent level, respectively

Appendix C Table C2 Regression Coefficients for Food Supply Responses in Tropical Africa and four main Agro-climatic Regions, 1974-89

Dependent variable Food Crop Output

Independent Variables	Eastern and Southern Region (ESA)	Sudano-Sahel Region (SSA)	Western Africa Region (WA)	Central Africa Region (CA)	Tropical Africa (TA)
Producer Price[1]	0 148***	-0 033	0 038	0 006	0 026
Lagged Dependent	0 265***	-0 086	0 235***	0 189**	0 168***
Weather Proxy	0 422***	1 261***	0 278***	0 123	0 357***
disaster Variable	-0.001	-0.002	-0 002*	-0 009*	-0 002***
Fertilizer Use	0.036	-0 008	0 000	0 009	0 002
Trend	0 016***	0.019***	0 016	0 035***	0 024***
Kenya	2 429***				3 767***
Malawi	2 253***				3 519***
Tanzania	2 273***				3 215***
Ethiopia	2 024***				3 550***
Madagascar	2.309***				3 495***
Rwanda	2.367***				3 763***
Zambia	2 438***				3 443***
Sudan		4 985***			3 466***
Gambia		5 042***			3 636***
Senegal		5 258***			3 673***
Burkina F.		5 307***			3 586***
Nigeria			3.052***		3 533***
Liberia			2 982***		3 519***
Ivory Coast			2 973***		3 636***
Ghana			3 085***		3 546***
Togo			3 019***		3 638***
Central A R				3.52***	3 873***
Congo Rep				3 735***	3 569***
Cameroon				3 439***	3 594***
Zaire				3 449***	3 987***
Number of observations	105	60	75	60	300
Buse R-square	0 99	0 99	0.99	0 99	0 999

Notes 1. the food crop output, producer prices, weather proxy and fertilizer use are expressed in logarithm Their coefficient may be considered as an elasticities 2 Producer price is the aggregate food prices lagged one period (t-1)

*, **, *** imply significant at the 10, 5 and 1 percent level, respectively

APPENDIX D: REGRESSION COEFFICIENTS OF POOLED MODEL IN TROPICAL AFRICA AND MAIN AGRO-CLIMATIC REGIONS (LINEAR AND LOG-LINEAR FUNCTIONAL FORMS)

APPENDIX D Table D1 Coefficients of Pooled Model for Export Supply Responses in Tropical Africa and Main Agro-climatic Regions (Linear), 1974-89

Dependent variable: Export Crop Output

Independent Variables	Eastern and Southern Region (ESA)	Sudano-Sahel Region (SSA)	Western Africa Region (WA)	Central Africa Region (CA)	Tropical Africa (TA)
Producer Price[1]	6.387**	-8 13	17.026***	4 148**	2.477**
Lagged Dependent	0.833***	0.489***	0.650***	0.406**	0 773***
Weather Proxy	-3 576	63.08**	20 874*	-5 441	15.142**
disaster Variable	-0.039(0 14)	-0.733***	0 016	0 059	0 026
Fertilizer Use	0 097(1.00)	1.939***	0 326	-1 986	0.189**
Trend	0.846**	0.407	0 487	0.487	0 443***
Constant	4.550	78.313***	13.480*	58.735***	17.161***
Number of observations	105	60	75	60	300
R-square	0 991	0 93	0 99	0 98	0 99
SSE	54 26	31 31	38 81	38 81	149 5

1 producer price is the ratio of two year moving average of the export prices and current food prices
*, **, *** imply significant at the 10, 5 and 1 percent level, respectively

APPENDIX D. Table D2 Coefficients of Pooled Model for Export Supply Response in Tropical Africa and main Agro-climatic Regions (Log-linear), 1974-89

Dependent variable Export Crop Output[1]

Independent Variables	Eastern and Southern Region (ESA)	Sudano-Sahel Region (SSA)	Western Africa Region (WA)	Central Africa Region (CA)	Tropical Africa (TA)
Producer Price[2]	0.089**	-0 003	0.273***	0 016	0 0450***
Lagged Dependent	0.630***	0.430***	0.427***	0.410**	0 708***
Weather Proxy	-0 023	0.379**	0 126	-0 224	0 109
disaster Variable	-0 002	-0.006***	-0 001	0 000	-0 001
Fertilizer Use	-0.036**	0.148***	0 010	-0 035	0 003
Trend	0.016***	-0 0002	0.009**	-0 035	0.007***
Constant	1.903***	1.610***	2.458***	2.933***	1 128***
Number of observations	105	60	75	60	300
R-square	0 99	0 99	0 99	0 99	0 99
SSE	54.95	31 08	38.6	29 87	155 71

1 The Export Output, Producer price, Weather Proxy and Fertilizer uses are expressed in logarithm
2 Producer price is the ratio of two year moving average of export and current food prices
*, **, *** imply significant at the 10, 5 and 1 percent level, respectively

APPENDIX D Table D3 Coefficients of Pooled Model for Food Supply Responses in Tropical Africa and Main Agro-climatic Regions (Linear),1974-89

Dependent variable Food Crop Output

Independent Variables	Eastern and Southern Region (ESA)	Sudano-Sahel Region (SSA)	Western Africa Region (WA)	Central Africa Region (CA)	Tropical Africa (TA)
Producer Price[1]	**0.079****	0.099	0.031	0 038	0 020
Lagged Dependent	**0.684*****	0 039	**0.399*****	**0.650*****	**0.547*****
Weather Proxy	**38.771*****	**114.47*****	**25.345*****	-13.457	**28.321*****
Disaster Variable	-0 072	-0 016	-0 089	-0 202	-0 071
Fertilizer Use	**0.441*****	**-0.687****	-0 441	**4.380*****	0.129
Trend	**0.973****	**2.210*****	**3.006*****	**2.112*****	**2.152*****
Constant	**13.500****	**84.638*****	**44.67*****	**17.46***	**31.33*****
Number of observations	105	60	75	60	300
R-square	0 98	0 98	0 98	0.99	0 99
SSE	54 53	30.01	36 57	28.78	149.5

Note 1 producer price is the aggregate food prices lagged one period (t-1) *, **, *** imply significant at the 10, 5 and 1 percent level, respectively

APPENDIX D Table D4 Coefficients of Pooled Model for Food Supply Response in Tropical Africa and the Main Agro-climatic Regions (Log-Linear),1974-89

Dependent variable Food Crop Output[1]

Independent Variables	Eastern and Southern Region (ESA)	Sudano-Sahel Region (SSA)	Western Africa Region (WA)	Central Africa Region (CA)	Tropical Africa (TA
Producer Price[2]	**0.060***	**0.182****	0 012	0.027	0.017
Lagged Dependent	**0.764*****	-0 020	**0.353*****	**0.537*****	0.488***
Weather Proxy	**0.309*****	**1.228*****	**0.264*****	-0 079	**0.278*****
Disaster Variable	**-0.309*****	-0 002	-0 001	-0.003	-0 001
Fertilizer Use	**0.018***	-0 041	0 008	0 023	-0 008
Trend	**0.111*****	**0.017*****	**0.028*****	0.023***	**0.019*****
Constant	**0.606****	**4.161*****	**2.691*****	**1.753*****	**2.10*****
Number of observations	105	60	75	60	300
R-square	0 99	0.99	0.99	0 99	0 99
SSE	53 95	30.30	37 2	27.63	131.10

1 The food crop output, Producer price, Weather Proxy and Fertilizer use are expressed in logarithm.
2 producer price is the aggregate food prices lagged one period (t-1) *, **, *** imply significant at the 10, 5 and 1 percent level, respectively